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Edited by Tony Cullen and Christopher F Foss





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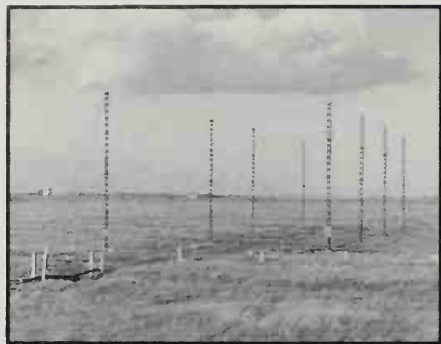
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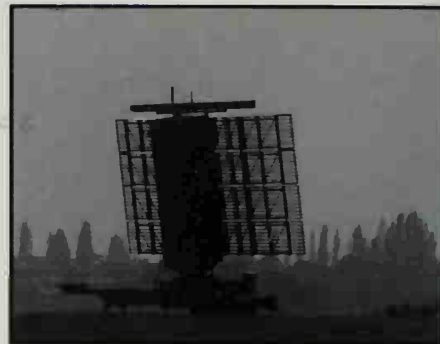
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# JANE'S LAND-BASED AIR DEFENCE

FIFTH EDITION

EDITED BY  
TONY CULLEN and CHRISTOPHER F FOSS

## 1992-93

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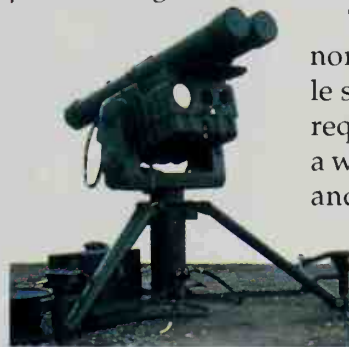




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# JANE'S LAND-BASED AIR DEFENCE 1992-93

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# Foreword

The start of 1991 saw the full might of UN sanctioned Coalition forces thrown against the regional Super Power, Iraq, to liberate the small Gulf country of Kuwait and bring Iraq's infrastructure virtually back to where it was at the country's birth.

At a conservative estimate the Iraqi strategic and battle-field air defence forces fielded a total of: 17 000 SAMs of the SA-2/SA-3/SA-6/SA-7/SA-8/SA-9/SA-13/SA-14/SA-16/HN-5/Roland types; some 9 to 10 000 AAA guns of the 14.5 mm ZPU-1/ZPU-2/ZPU-4, 23 mm ZU-23, 23 mm ZSU-23-4, 30 mm M53/59, 30 mm M53/70, 35 mm GDF-001, 37 mm M1937, 37 mm Type 55, 57 mm S-60, 57 mm Type 59, 57 mm ZSU-57-2, 85 mm KS-12, 100 mm KS-19 and 130 mm KS-30 types; and 13 squadrons (totalling around 310 aircraft) of MiG-21 Fishbed F/J, Xian F-7B, MiG-23 Flogger E, MiG-25 Foxbat A/E, MiG-29 Fulcrum A and Mirage F-1EQ interceptors armed with AA-2 'Atoll', AA-8 'Aphid', AA-6 'Acrid', AA-10 'Alamo', AA-11 'Archer', Magic R550 and Super R530 air-to-air missiles.

Iraq itself was divided into four air defence regions, each with a major command and control operations centre and covert backup facility. These regional centres were administered by the central Air Defence Command Centre complex in Baghdad, connected by high technology communications and data link systems and serviced by an extensive integrated network of both Western and Soviet supplied early warning/surveillance radars. These included amongst others 'Tall King', 'Spoon Rest', 'Squat Eye', 'Barlock', TRS-2215 and TRS-2230 types.

A limited amount of force multipliers were also available to the air defence forces in the form of an airborne AWACS system, which was at the prototype stage (with at least three Ilyushin Il-76 'Adnan' AEW aircraft modifications flying in two distinctly different configurations), and an air-to-air refuelling force of locally modified tanker versions of Antonov An-12 'Cubs' and Ilyushin Il-76 'Candid' transports.

The key to the Coalition's dramatic destruction of these defences was the time taken for the war to happen. Whilst all eyes were on the build up of the Coalition air, ground and naval Desert Shield forces in the region and the political posturing at the United Nations, the electronic intelligence gatherers were patiently building up the Iraqi air defence order-of-battle (ORBAT) using every available type of allied strategic and tactical air, sea and spaceborne platforms to obtain COMINT, ELINT, IMINT, PHOTINT, RADINT, TELINT and, wherever possible, HUMINT data from special forces units on the ground for the collation process.

The myriad of processed information was then fed into the Coalition's air-land battle master plan for targeting and planning purposes, and used tactically to help reconfigure allied ECM systems and adapt electronic threat signature libraries to cover Western designed equipment and previously unknown Soviet systems in the Iraqi inventory.

Once all this information was assimilated, the planning and training completed and political approval given for the attack to commence then the Coalition force unleashed its precision air and seaborne strike assets on the nights of

16/17 January 1991 to seize air superiority and start the strategic phase of the plan so as to inflict strategic paralysis upon the Iraqi military machine.

Selective attacks by BGM-109 cruise missiles and Lockheed F-117A Stealth fighter-bombers (armed with precision laser-guided munitions) were targeted against the most heavily defended areas, especially the intelligence identified hardened military associated communications, headquarters and air defence control nodal centres. The F-117s alone hit 37 major targets in Kuwait and Iraq on this night without being detected. The follow-up strike packages, involving formations of aircraft flying at low level and high speed and supported by various ECM, tanker, defence suppression (Wild Weasel) and fighter escort aircraft to counter Iraqi radars and interceptors, then used the Iraqi air defence ORBAT information and, where feasible, aid from E-3B Sentry AWACS aircraft to route themselves around the most heavily defended areas to complete co-ordinated attacks on other military and strategic infrastructure targets. Although 668 aircraft attacked Iraq on the first night (530 US Air Force, 90 US Navy/Marine Corps, 24 British, 12 French and 12 Saudi Arabian) no aircraft were lost. By midnight on 17 January over 1300 combat sorties had been flown for the loss in combat of six aircraft (a USN F/A-18C Hornet, USN A-6E Intruder, Kuwaiti A-4KU Skyhawk, two RAF GR-1A Tornados and an Italian IDS Tornado).

The Coalition loss rates experienced on the first day and for the rest of the Desert Storm period remained staggeringly low for the number of aircraft committed and the 109 876 sorties flown over the entire 43 day war. Only 38 Coalition aircraft were classed as combat losses (14 US Air Force, 8 US Marine Corps, 7 US Navy, 1 Kuwaiti, 1 Italian, 1 Saudi Arabian and 6 British). Of these, 10 were assessed as being lost to SAMs and the majority of the remainder to Iraqi 'Golden BBs' (the Iraqi anti-aircraft artillery). One area of Iraqi air defence which does merit special consideration is that SA-8 and ZSU-23-4 systems did shoot down a number of the cruise missiles. A significance that has not been unnoticed in other quarters where air defences are of a considerably better quality.

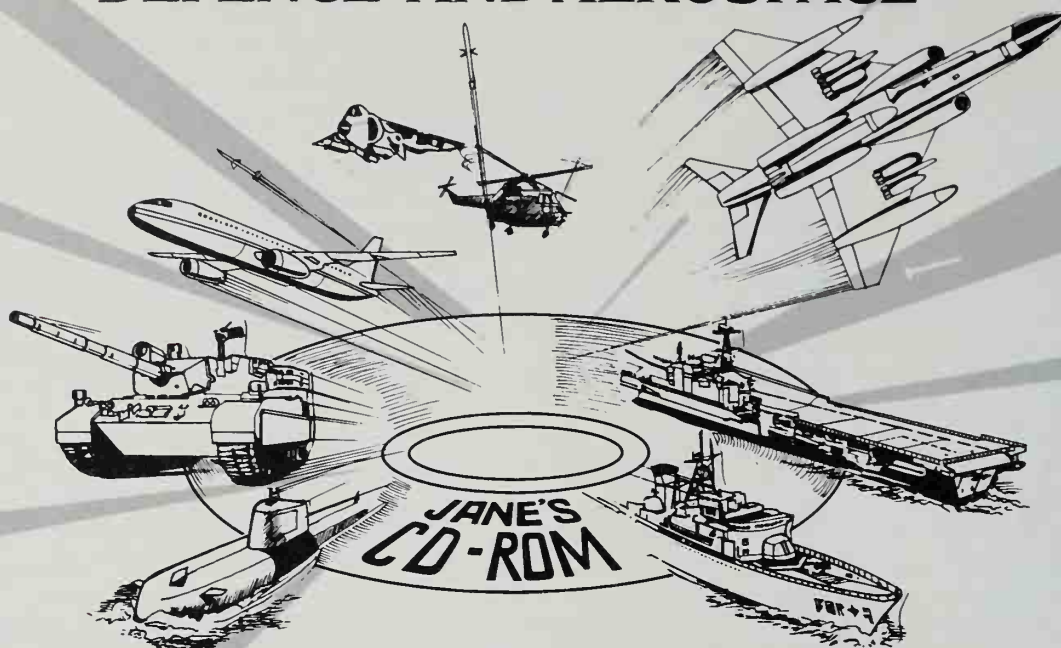
Although the aircraft losses were relatively small in number, it should not be forgotten that the Iraqi air defence systems also managed to damage a considerable number of other Coalition aircraft and prevent others from reaching their primary targets. Which is in reality what the air defences are there for, and not to shoot down masses of aircraft.

The Coalition side also emplaced its own air defence network in Saudi Arabia to cover its field forces and bases, using the infrastructure already present with the Saudi Arabian air defence forces, the various Gulf states and such weaponry as the MIM-104 Patriot, Rapier and Crotale flown in as part of the Desert Shield build up. The national air defences of Israel and Turkey were also augmented during the war by deployments of Patriot air defence missile systems and, in the case of the latter country, Roland systems.

Although primarily assigned to the anti-aircraft role the Patriot system started on Friday 18 January to take on its

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role in the war as the 'Scud Buster', when a US Army Patriot battery firing PAC-2 standard missiles specifically deployed to support allied forces successfully engaged an Iraqi 'Scud' in-bound to Dharan. Contrary to popular belief held by numerous 'experts' during the war the Patriot's effectiveness against the 'Scud' was not something that arrived miraculously overnight, but was the result of a continuing in-field development process which evolved to meet problems as they arose during the combat operations. In fact, during the period of Desert Shield/Desert Storm a total of 35 separate modifications were made to the Patriot system software, including the early fielding of the Build-3 software package. In short Patriot did the job it was required to do.

The ramifications of the war, however, are being felt throughout the world. In America it is felt that there is a need to provide an adequate air defence for unit operations in the field which will protect against all types of attack from air-breathing systems to Tactical Ballistic Missiles (TBMs). The systems designed to provide this protection are being developed under various programmes such as THAAD and Corps SAM. The procured systems will eventually be integrated into a layered defence network and either replace or complement the current air defence weapons.

The then Soviet Union embarked upon a thorough review of its complete air defence network and the changes it requires because of the lessons from the war. The combat debut of 'Stealth' and cruise missiles were of particular concern but they are matched by the sophistication and competence of the latest generation of Soviet missile systems, which are slowly being revealed to the West as information and photographs are released by their former Warsaw Pact allies and the system manufacturers themselves. The latter, in both the Soviet technical press and at the various defence shows they now attend.

The S-300 (SA-10 'Grumble') appears every bit as able as the Patriot whilst the ZRK Tor (SA-15) is the world's first operational land-based vehicle-mounted vertical launch SAM with characteristics similar to Roland. However, the disintegration of the Soviet Union into various independent states and loose confederations brings into question the fate of the whole centralised Soviet armed forces, including its air defence troops. It also brings the prospect of four separate nuclear states - Russia, the Ukraine, Byelorussia and Kazakhstan. The answer to all this is not by any means clear and straightforward and it would appear that only time will allow one to be established.

In the UK the death of the faithful old 'Dog', the Bloodhound Mk 2, was finally announced in mid-1991. Laid to rest as being non cost-effective by the RAF, despite the millions spent on the system over the last decade or so to prevent it being so, it would appear that Bloodhound became one of the victims of the officially 'non-existent' interference by the UK Treasury in MoD cost matters. A replacement is being looked for but the wording on the documentation sent out to industry would appear, in the now typically British fashion on such defence matters, to do what appears to be the right thing whilst leaving every conceivable option open to do absolutely nothing as the political situation allows. In short the basic problem is Britain now has no long-range air defence missile system available and is not likely to have any until the mid- to late 1990s, if at all. This is a decision which must surely

eventually rank alongside those infamous decisions of the 1957 White Paper (which essentially ruled out all named fighters other than the P-1 Lightning for the RAF in lieu of guided missiles) and the 1966 Defence Review (which killed conventional aircraft carriers for the Royal Navy and effectively left tactical air power at sea in the 1970s to land-based aircraft provided and operated by the RAF).

The British Army will suffer its own air defence problems in that as part of the restructuring it is undergoing the Tracked Rapier system will be withdrawn from use. Its *de facto* replacement will be the Shorts Starstreak self-propelled HVM system. However, some plaudits must be given to the MoD and the British Army in the fact that the Shorts Starburst manportable SAM system came as a pleasant surprise to the military world during Desert Shield/Desert Storm. A British missile system which deserves considerable success on the world's air defence market as a worthy rival to competing French, Swedish and American manportable systems.

A little known fact about another British SAM system which deserves wider acclaim, especially in the light of the potential chemical warfare threat in the Gulf, is that the BAe Rapier 2000 system has been specifically built with chemical hardening features designed into the individual components. A practice that is heartily welcomed by its users and which will make its operational use under NBC conditions considerably easier than current systems.

In France the Crotale NG SAM system has been ordered for the French Air Force which will provide additional impetus for it to be sold on the world market, especially as traditional French customers in the Middle and Far East review their air defence requirements in the light of the Gulf war.

Kuwait has to virtually rebuild its defence forces from the ground up, whilst Saudi Arabia and the various Gulf states will need to bolster their air defence forces with additional equipment. The knock on effect will also spread throughout other countries in the immediate area and into neighbouring regions where conflicts of similar proportions could flare up easily.

The potential use of the Scud TBM to deliver chemical and/or biological weapons is one scenario which is spreading disquiet, especially as of mid-1990 some 23 countries had been confirmed or suspected of having chemical warfare programmes. A total of 10 have or were suspected of having biological warfare programmes and, by the year 2000, 15 developing countries would have the technological capability to build their own TBMs. The figure of 15 includes 6 countries which will have IRBM type systems available by the turn of the century, but does not include the countries which can afford to buy TBM/IRBM missiles on the international arms market. In addition, some of the countries now developing their own missiles have nuclear weapons programmes, which means a missile delivered nuclear option will exist for them.

Of the most well known problem areas the threat of Arab TBMs with various conventional and chemical/biological weapon type warheads has already spurred Israel into a co-venture with the United States, the Arrow (Chetz) programme. Whilst in the Far East, Taiwan has utilised imported Patriot technology in its own Tien Kung family of surface-to-air missiles, which may ultimately prove to have a limited ATBM capability.


The need for South Korea and Japan to have some

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ATBM capability is driven by the continuing presence of the massive North Korean offensive missile and mass destruction weapon development programmes.

Rapid changes in Eastern Europe, including the break up of the Union of Soviet Socialist Republics (USSR), has led to a considerable amount of new information becoming available on some of the more recent Soviet air defence systems.

In the last 18 months, the former USSR started to market some of its latest weapon systems in the Middle East and elsewhere, which has led to a significant amount of new information being released on a number of weapon systems, including the unique 2S6 self-propelled air defence system combining both guns and missiles, the SA-10 Grumble SAM system and the SA-15 Tor system that utilises vertically launched SAMs.

In the past, such advanced systems were not normally released for the export market until some years after they had been in service with the Soviet armed forces, and their early release for export indicates the degree to which they require foreign exchange to boost their bankrupt economy.

Information on some of the other Soviet air defence systems which have been in service for many years, for example the SA-11 Gadfly, is still difficult to obtain, as is information on more recent systems. Hopefully this situation will change in the future.

Marconi Radar and Control Systems has now delivered the first three production Marksman twin 35 mm air defence turrets to Finland where they have been integrated onto existing T-54/T-55 MBT chassis. Finland holds an option on an additional batch of Marksman turrets which is still to be exercised.

In the US, trials with the two competing designs of the Light Armored Vehicle - Air Defence (FMC and General Electric being the contenders) have been completed and one is expected to be selected for final development and production in the near future. Both contenders for the above are based on an 8 × 8 chassis provided by the Diesel Division, General Motors of Canada and feature a two man power-operated turret armed with a 25 mm cannon and Stinger fire-and-forget missiles. Typically the Stinger would be used to engage targets at a longer range with the 25 mm cannon being used over shorter distances.

The Soviet 2S6 gun/missile air defence system, which has been in service for several years, has similar capabilities and effectively integrates the two complimentary weapon systems into a highly capable air defence system which can engage a variety of battlefield targets.

First details were also released in 1991 of the private venture General Dynamics/RAFAEL High Value Site Defense (HVSD)/Air Defence Advanced Mobile System (ADAMS), with a full scale mock-up being shown at the Paris Air Show. This combines two well known weapon systems, the US General Dynamics 20 mm Phalanx Close-In Weapon System (CIWS), originally developed for naval applications, and the Israeli RAFAEL Barak-1 vertically launched missile originally developed for naval applications.

There is little to report in towed anti-aircraft gun systems, indeed Oerlikon-Contraves has now stopped marketing their twin 25 mm Diana light anti-aircraft gun system and their 25 mm infantry gun Iltis. They have also stopped all work on the Escorter twin 35 mm self-propelled air defence system on a 4 × 4 high mobility cross-country truck chassis. Oerlikon-Contraves continue to manufacture and market their highly effective twin 35 mm towed anti-aircraft gun systems as well as a variety of upgrade packages for these weapons.

A number of countries are now looking at fitting their existing anti-aircraft guns with new sighting systems and the latest details of these are given in the *Towed Anti-aircraft Gun Sights* section.

### Addenda

This edition of *Jane's Land-Based Air Defence* has some 22 new entries and over 150 photographs, many of which have not appeared before.

As this issue was going to press, South Africa released details of three new air defence systems, the ZA-35 twin 35 mm self-propelled anti-aircraft gun system on the Rooikat 8 × 8 armoured car chassis, the Crotale SAM upgrade package and the ZA-HVM self-propelled SAM system. The latter consists essentially of the ZA-35 with the twin 35 mm cannon replaced by the SAHV-3 missiles used in the Crotale upgrade package.

Details of all three of these systems are given in the addenda.

### Acknowledgements

The editors would like to take this opportunity to thank the many manufacturers, defence forces and private individuals who have contributed to this edition of *Jane's Land-Based Air Defence*.

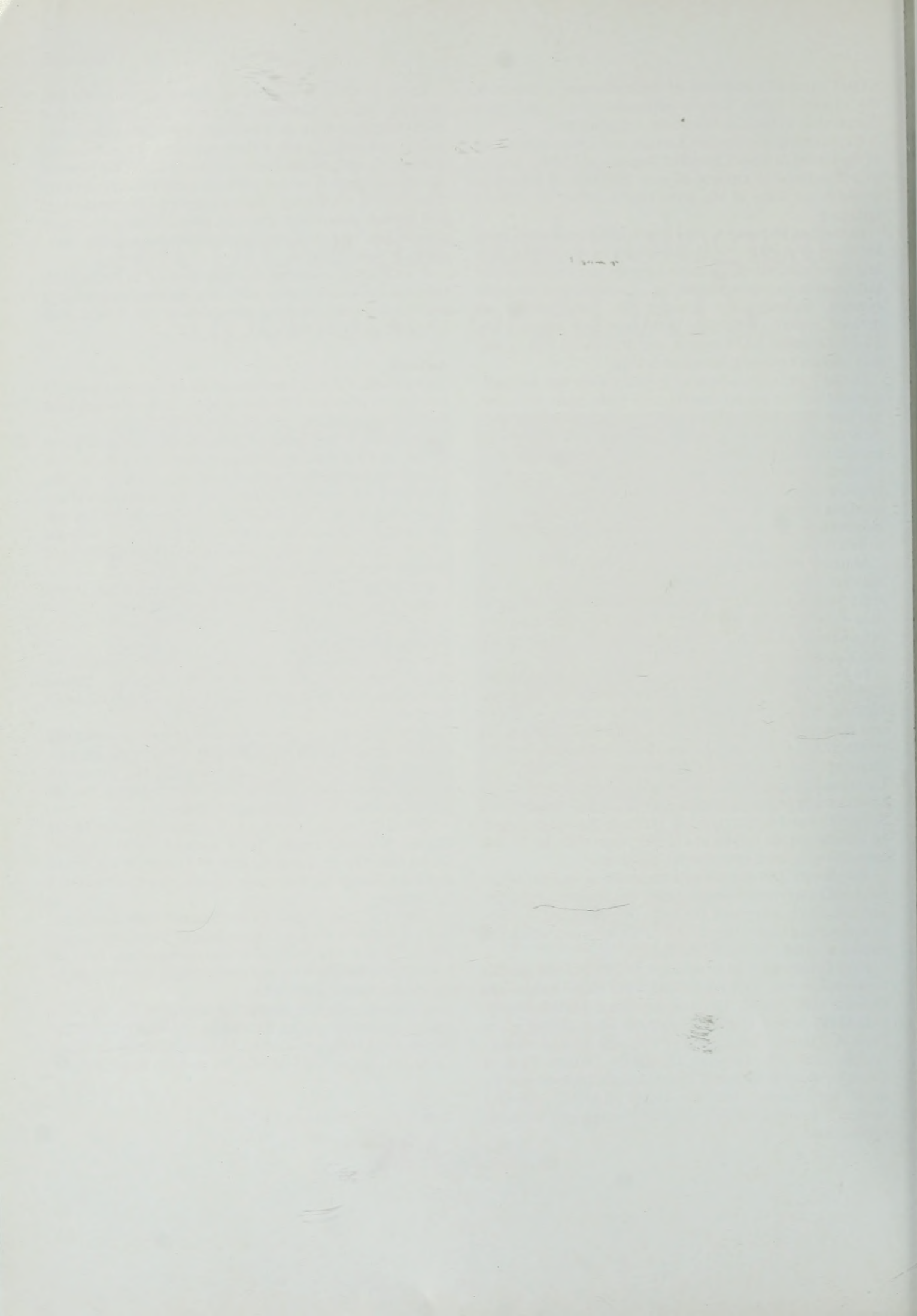
Special thanks are due to Bernard Blake who compiled the first section and Duncan Lennox for his input on anti-tactical ballistic missile defences. Additional details on strategic weapons, including defensive systems, can be found in *Jane's Strategic Weapon Systems*.

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Additional information and photographs for the sixth edition should be sent to the editors at Jane's Information Group, Data Division, Sentinel House, 163 Brighton Road, Coulsdon, Surrey CR5 2NH, UK, as soon as possible.

Tony Cullen, Christopher F Foss  
January 1992





# National and International Air Defence Systems

**Note:** Many countries now have an air defence system based primarily on long- and medium-range radar equipments. The size of these systems depends to a large extent on what individual countries can afford and the degree of likely threat. There are some highly comprehensive and sophisticated systems such as those forming the defensive shields of the United States and Soviet Union which incorporate several different types of radar and air defence missiles, and are intended to counter the threat of ballistic missile, cruise missile and manned aircraft attacks. Another comprehensive network is NADGE (NATO Air Defence Ground Environment), which covers most of Western Europe. National systems tend to be somewhat simpler and can vary from one or two radar equipments placed at strategic points on the periphery of the particular country to more complex systems such as Britain's UKADGE, the French STRIDA and the

Saudi Arabian Peace Shield. During the past decade the use of mobile or transportable radar-based systems has become more prevalent, this enables a network to be moved rapidly, making it less vulnerable to air attack.

Air defence is a particularly sensitive subject and consequently information on some nations' systems and equipment is somewhat limited. Political as well as military reasons are frequently the cause of manufacturers' reluctance to divulge the destination of equipments such as radar or computers, which might otherwise enable assessments of the air defence provisions of particular countries.

It should be noted that many countries have a link-up between their civil air traffic control system and their air defence network. This gives them greater management and coverage of the airspace, as well as a backup in times of national emergency.

## ABU DHABI

Due to long-running problems in the Gulf area, Abu Dhabi has initiated an urgent requirement for an air defence system which includes both radar and the necessary communications links. Equipment to the value of around \$700 million is involved and the United States, United Kingdom and Soviet Union have had discussions with Abu Dhabi. These discussions started

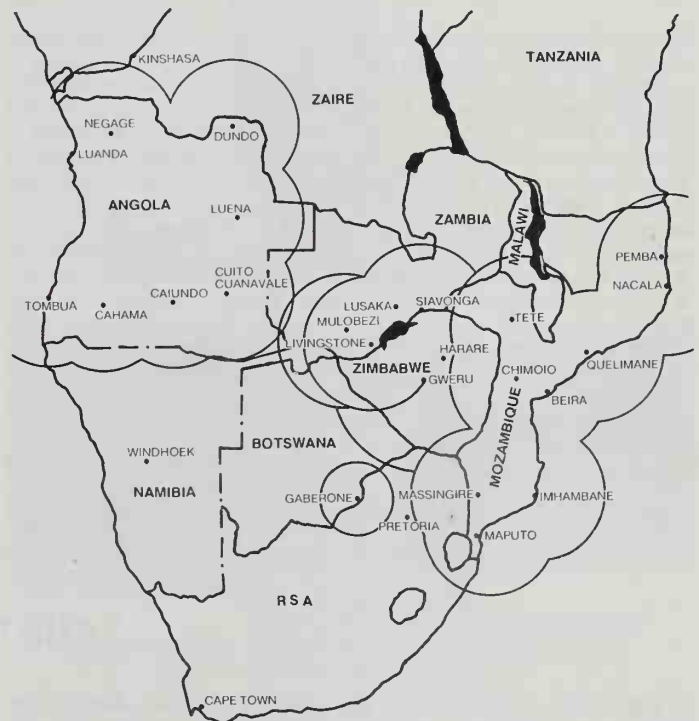
during 1987 and, as yet, no announcements have been made as to their progress or the type of equipment being sought. Since Abu Dhabi is part of the United Arab Emirates (see later) it is almost certain that any air defence requirements will form part of an overall UAE system.

## SOUTHERN AFRICA

This area covers Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. It does not include the Republic of South Africa. Angolan air defence is described under a separate entry.

In general, Southern Africa has been supplied with both ground and airborne air defence equipment from Soviet sources, however, in some cases Chinese aircraft and AA guns are in operational use. Although there appears to be no centralised air defence the area is well supplied with surveillance radar systems, most of which are Soviet types, and it is assumed that each country operates its own air defence centre. The accompanying diagram gives locations of those sites that have been identified, together with their coverage on 1 m<sup>2</sup> target at 6096 m. Soviet radars in operational use include Bar Lock, Spoon Rest, Flat Face, Side Net, Odd Pair, Squat Eye and Thin Skin. Most of the SAMs deployed are also of Soviet types, including SA-2, SA-3, SA-6, SA-7, SA-8, SA-9 and SA-13, plus AA guns of various types and calibres.

More recently, the various countries of Southern Africa have turned to the West for defence products. An example of this is the Watchman radar delivered to Zimbabwe late in Autumn 1991. Although this system is for ATC purposes at Harare, it can be easily incorporated into the air defence network.

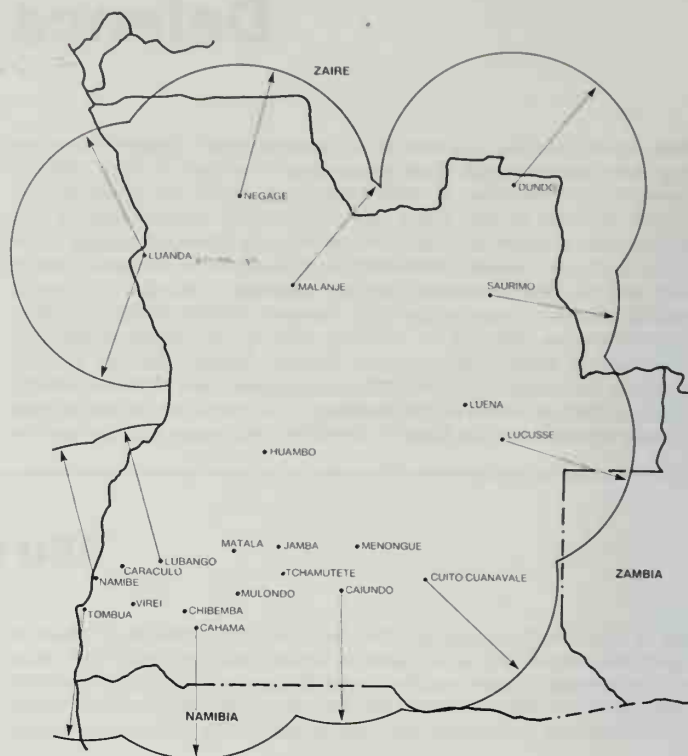


## ANGOLA

For reasons that are not difficult to understand, very little is known about the air defence systems operating in Angola. Virtually all radar systems and other military equipment have been supplied by the Soviet Union and much of it is operated by Cuban personnel, although the latter are being withdrawn under the Brazzaville agreement. Over 20 radar sites using a variety of Russian surveillance and search radars have been identified including Tall King, Spoon Rest, Bar Lock, Flat Face, Squat Eye and Side Net systems. The accompanying diagram gives location of the radar sites that have been identified, with coverage up to 6096 m.

The Angolan Air Force, maintained and operated largely by Soviet and Cuban personnel, consists almost entirely of Soviet aircraft with a small number of other types. The main strike force consists of MiG-17, MiG-21 and MiG-23 aircraft with a few Su-22 ground attack aircraft. The strike force appears to number around 160 aircraft. In addition there are large numbers of helicopters, mainly of French and Soviet manufacture, and a mixture of transport types.

Surface-to-air missiles in operational deployment include SA-2, 3, 6, 7, 8, 9, 13, 14 and 16.



Map of Angola with radii showing radar range of up to 6096 m

## ARGENTINA

With the changes in government after the Falklands campaign against the United Kingdom, very little has emerged from Argentina on the subject of air defence. It is known that a programme for an integrated air defence/ATC was being carried out in the 1970s by Thomson-CSF of France but the extent of this has not been made public. It is believed to be similar in principle to that provided for Brazil. In 1985 the President of Argentina introduced a new plan to reorganise the defence of the nation, with a new National Defence Council replacing the former military committee. The council was established in 1988 and responsible for carrying out wide-ranging defence structure and planning. Until the Anglo/Argentine hostilities in 1982, Argentina was spending somewhere in the region of eight per cent of its GNP on defence - by far the highest proportion in South or Central America. During the early part of 1989, Argentina was reported to be considering a defence equipment procurement bill totalling \$4 billion spread over the five years. This amount is in addition to the current defence budget allocation. With the very high inflation rate in Argentina it is difficult to assess what this really means in terms of actual expenditure, and whether the economy can actually afford it.

During the late 1970s three Westinghouse AN/TPS-43 radars were procured and a number of Cardion-built AN/TPS-44 systems were also supplied. No official information has been disclosed but it seems likely that

these systems were deployed to afford cover for the main naval and air bases near Buenos Aires, Port Belgrano, Comodoro Rivadavia, Santa Cruz, Rio Gallegos, Rio Grande and Ushuaia. In 1982 one of the AN/TPS-43 radars was deployed in the Falklands and subsequently captured by the British forces. After being refurbished in the UK it returned to the Falklands and is now based at Port Stanley. It seems likely that early steps were taken to replace this item following Argentina's withdrawal from the Falklands, either with another AN/TPS-43 or a similar type such as the Thomson-CSF TRS-2215 or TRS-2230. It has also been reported, although not confirmed, that Argentina has recently placed an order for a number of Selenia RAT-31S radar systems.

The Argentine Air Force is quite extensive and includes the A-4 Skyhawk, Mirage IIIEA/IIICJ and IAI Dagger A/Mirage V, as well as two COIN squadrons equipped with Pucara aircraft. The Daggers and Mirage V have been upgraded with a new electronics package and the planned acquisition of 24 ex-Israeli A-4s is still likely. In addition, Argentina has opened initial talks to obtain a number of AMX fighter-bombers.

The surface-to-air missile force is operated by the Argentine Army Marine Corps and consists of a variety of French, British and Soviet missiles, including Roland, RBS 70 and Tigercat, plus the manportable SA-7 and Blowpipe.

## AUSTRALIA

A wide-ranging defence strategy was outlined in a Defence White Paper produced in March 1987. It committed Australia to high quality intelligence together with flexible, long-range capabilities for maritime surveillance and interdiction, aimed at denying effective use of the sea or air to the north of the country to any hostile nation. The 1990 defence budget was set at \$8.372 billion (US\$6.5 billion) which represented zero growth on the previous year. In May 1991 a major restructuring of the defence forces was announced which will cut 5200 personnel from the army, 4200 from the air force, 1020 from the navy and 3840 civilians. The cuts will save \$1.57 billion over the next 10 years.

The restructuring represents a major policy change and allows a surge combat capability for the front line F-111 and F/A-18 aircraft for the RAAF by allowing former air crew to continue flying the aircraft as members of a

newly formed reserve force. It has been calculated that the F-111s can be operated until the year 2010 and it is likely that both the F-111s and the F/A-18s will eventually be replaced by the one type.

Other than the strike force of F-111s and F/A-18s, the major elements of the new strategy for air defence are the development of the Jindalee over-the-horizon radar and upgrading of the P-3C maritime surveillance aircraft. The latter includes the replacement of the aircraft's surface surveillance radar. As an additional force to be integrated with the Jindalee radar, it was announced in 1988 that Australia intended to procure a number of airborne early warning aircraft. Three airframes were under consideration, the Boeing E-3 Sentry, the Lockheed P-3 Orion and the Lockheed C-130, but by mid-1991 it was apparent that interest was centring on a smaller and cheaper system. In late 1991, the leading contender for this procurement appears to



be the Ericsson PS890 radar-based AEW system which, under the name of Erieye, has been extensively flight tested in a Fairchild Metro commuter aircraft.

The original air defence system was known as Hub Cap and provided three-dimensional airspace surveillance and fighter control to intercept hostile aircraft over a wide area. It operates from fully mobile air-conditioned shelters designed for deployment by C-130 aircraft. Since the sparse population and continental size of Australia combine to make a conventional static air defence organisation, similar to that of the USA, an unrealistic proposition, an effective compromise was achieved by the combination of two Hub Cap systems, with the search radars and part of the infrastructure needed for the control of civil and military air traffic serving the main population centres of the country. The new strategy will update Hub Cap and implementation is being carried out currently and over the next few years. The original Hub Cap radars were replaced by three Westinghouse AN/TPS-43 radars and the sites were subsequently rewired with fibre optic cabling for enhanced operator safety. A tactical air defence system, also supplied from Westinghouse, is operational and allows for radar-directed control of defensive fighter operations wherever the system is deployed.

The use of digital computing allows automatic tracking of targets from primary radar, while plot extraction from the secondary radar returns is used to reinforce the primary radar auto-tracking. For the RAAF requirements the computer is programmed to take into account aircraft characteristics, perform an assessment of an interception situation when supplied with the relevant data on weapon availability and provide a number of alternative intercept solutions for selections by the controller. Comprehensive communication facilities are also provided with the Hub Cap system.

Construction of a backscatter over-the-horizon (OTH-B) radar for the detection of aircraft, ballistic missiles and ships was first revealed in 1974.

Code name for the project is Jindalee. An experimental narrowbeam Jindalee system, operated from a site near Alice Springs, indicated that the future surveillance of the Australian coast and offshore regions could be undertaken by this technique. As a result of these tests a larger and more powerful version, with greater transmitter power and a larger receiving antenna, was constructed and produced highly successful results. It has now been confirmed that a network of three, possibly four, Jindalee OTH radars will be constructed.

In December 1990, it was announced that a consortium of Telecom Australia, GEC-Marconi of UK, and Lockheed Technology had been awarded an A\$907 million contract for development and production of Jindalee. In addition to upgrading the Alice Springs station, two other sites will be constructed, one at Laverton in central Western Australia and another near Longreach in central Queensland. A network co-ordination centre will be established at the RAAF base in Salisbury, South Australia. In the long term a fourth site may be constructed in the Northern Territory. The Jindalee system is scheduled to become operational in the mid-1990s.

It is interesting to note that a number of designers associated with Jindalee have claimed that it is able to detect 'stealth' aircraft by monitoring the air turbulence they generate in flight. The use of the HF waveband for over-the-horizon systems also helps in this connection and the combination would negate many of the advantages of this type of aircraft, if the claims are substantiated.

The Royal Australian Air Force is equipped with F-111C long-range attack aircraft which has been upgraded with the Pave Tack target acquisition and tracking system. The strike/interceptor force uses F/A-18s. For SAM applications the Army operates Rapiers equipped with Blindfire radar and manportable RBS 70.

## AUSTRIA

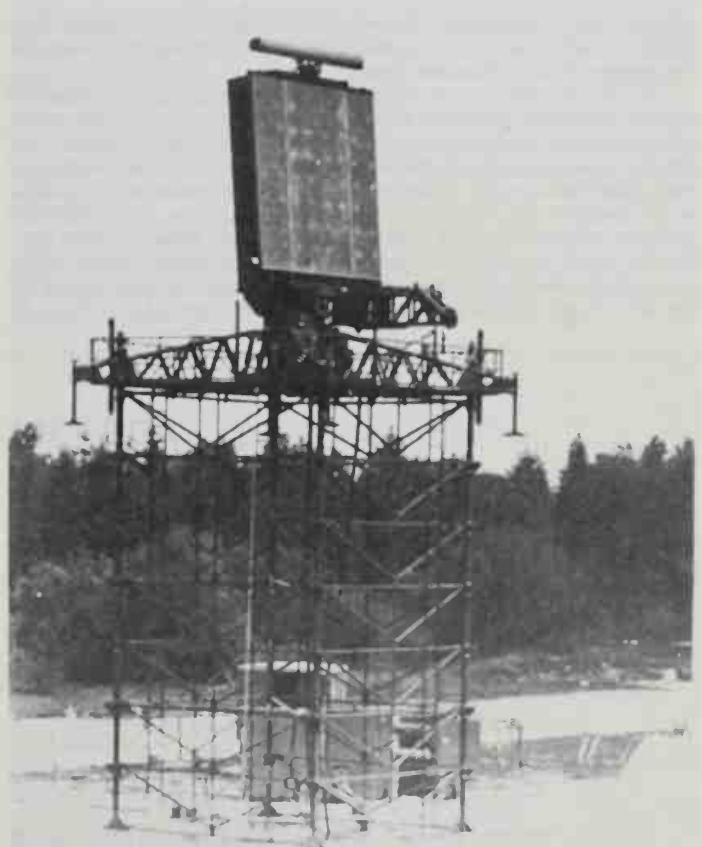
In the mid-1970s Austria commenced the planning of an integrated civil/military air surveillance system. The military part of the system was given the project name of Goldhaube, both military and civil parts are fully operational. The Goldhaube system consists of six medium-range 3D fixed radar stations, each equipped with SSR interrogators for use in the ATC role. Three of the radars are military and three civil, although all are used for military air surveillance as well as ATC purposes. The stations are at Kolomannsborg, Steinmandl, Speikkogel, Koralpe, Feichtberg and Buschberg. Two mobile radars were also acquired and fed into the overall network. These mobile systems can also operate autonomously and each is fully equipped with its own processing and display subsystem in an operations shelter. The radar data is transmitted via narrowband data links to an Air Defence Operations Centre and an Air Traffic Control Centre.

The six fixed radar stations are Selenia RAT-31S systems and the two mobile stations consist of the Selenia MRCS-403, which incorporates the RAT-31S as the basic radar. The main characteristics of the RAT-31S system are simultaneous range, azimuth and elevation measurements of targets at all altitudes, good ECCM performance and high resistance to ground/weather clutter.

The system produces an air situation picture which is transmitted back to the superior command centres via a narrowband data link, together with functions such as automatic track initiation, automatic tracking, automatic and/or manual height measurement and automatic track reporting. The



*Internal view of a Selenia MRCS-403 system operational shelter supplied to the Austrian MoD*



*The first Austrian site to be equipped with Selenia's MRCS-403 RAT-31S air defence radar*

system can process 3D low and medium altitude air situations and is able to perform autonomous control functions such as identification, interceptor control and missile control.

The operations shelter contains a dual computer, three display consoles, a communications control unit, and ground-to-air facilities. The computer is integrated locally with the 3D surveillance radar and for remote IFF/SSR

inputs the system is equipped with a data link interface for receiving plots. The computer-processed information is fed to the display subsystem as synthetic/alert track information and to remote centres as track information via a data link.

There is no Austrian air force as such, since all aircraft are part of the Army. In line with the Austrian neutral stance there have been no fighter/interceptor aircraft in the past, only types mainly devoted to army support

and reconnaissance. The Army, however, has taken delivery of 24 refurbished J-35D Draken aircraft as the J-35Ö.

In April 1989 the Austrian Army announced its intention to purchase its first SAM system in 1990 as part of an air defence modernisation programme. Manportable SAM systems under evaluation include Stinger, RBS 70, Javelin, Mistral and the SA-14 'Gremlin'. The programme also includes updating of the 35 mm GDF anti-aircraft guns.

## BELGIUM

As part of NATO, Belgium's air defence system is fully integrated into the NATO Air Defence Ground Environment (NADGE) system, and as such Belgian defence forces operate under NATO control. The Belgian Air Force has a number of fighter/ground attack squadrons comprising Mirage 5BA/D aircraft and F-16A/Bs. It had been the intention to buy a new generation of fighter aircraft, either Rafale, the EFA or the Agile Falcon, but under recent defence cuts this plan has been shelved. It is now likely that the country will

opt for a mid-life upgrade for its F-16s. The only SAM system currently in service is the Improved HAWK. A number of manportable Mistral systems are on order.

The 1990 defence budget was reduced to BFr104.7 billion (\$2.6 billion), a cut of some \$42 million, which reduced air force flying time, warship operations and army manoeuvres. Belgium will also withdraw about 1500 troops from duty in Germany over the next three years.

## BRAZIL

Brazil is in the late stages of the development of an integrated civil/military airspace surveillance and control system, which will be the culmination of a series of systems known as DACTA I, II and III. These represent stages of evolution of the complete system and comprise a vast radar and operations centre network, covering most of the Brazilian airspace, with Thomson-CSF in partnership with Brazilian industry. The complete system is under the control of CISCEA (Comissao de Implantacao do Sistema de Controle do Espaco Aereo). DACTA I was initiated in 1972 covering the central part of Brazil. This led to a series of phased extensions and updating programmes (DACTA II, DACTA III and Amazonia) to expand the coverage and modernise the original DACTA I at a later stage.

DACTA I uses the Thomson-CSF LP-23M long-range surveillance radars and RS 870 SSRs, supplying data to the Brasilia Regional control centre which provides radar control over the Rio/São Paulo/Brasilia triangle. The DACTA II phase relates to the introduction of TRS-2230 3D radars and more RS 870s to provide coverage and control over military and civil traffic in the southern part of the country from Curitiba centre. The completion of these two phases gives unbroken coverage of about 4 million km<sup>2</sup>. DACTA III will extend this coverage over the north-eastern region with a new regional centre at Recife. Two-dimensional primary radars with SSR are used in this phase of the programme. In total the DACTA II and III



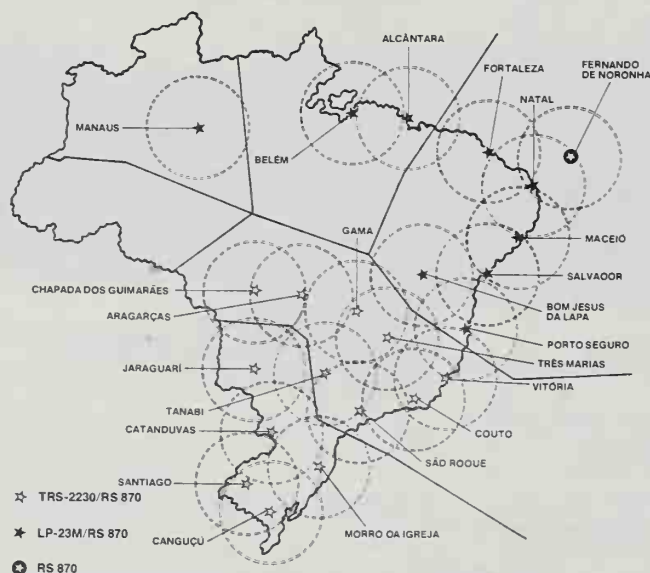
TRS-2230 3D surveillance radars and RS 870 SSRs like this will cover the entire southern Brazilian airspace when the Siscea ATC/air defence network is completed

phases entail the supply of a large number of long-range 3D radars, four approach radars and operations centres equipped with 20 to 30 consoles each. The final stage of the project is the implementation of the Amazonia phase which includes the provision of new surveillance radars and two new autonomous regional centres at Manaus and Belem.

Concurrent and interconnected with the project are numerous other radars (civil and military) which have been ordered and installed during recent years. Among such items are a number of Selenia RAT-31 3D surveillance systems, and various airfield surveillance and terminal area radars of French and Italian manufacture. A number of French height-finding radars were installed during the earlier years of DACTA I and it is likely that a significant proportion of these are still operational. At the Brasilia control centre, target data from search, heightfinder and SSR sensors are received via microwave links and processed by two automatic data processing systems. The computer programming is fully integrated and its functions include tracking of military and civil aircraft, interception for air defence, and flight plan processing for ATC purposes. The centre consists of separate operations rooms for ATC and air defence, and there is an automatic switching centre for message management and communications.

It is understood that both the DACTA I and DACTA II phases have now been completed and work on the upgrading of DACTA I and construction and installation of DACTA III is well under way. These phases involve replacement of some of the original radars; for example the LP-23M and Volex 3D equipments are being replaced by TRS-2230 systems. The number of systems being supplied during the DACTA III phase is uncertain but is at least 12. The original LP-23M and Volex radars could be used elsewhere such as the regional control centres at Manaus and Belem in the Amazonia phase of the programme. Completion of the Amazonia phase and implementation of the full five-centre system is estimated to take several more years, although by the end of 1990 radar coverage extended over the centre, south and north-east of Brazil, as well as part of Amazonia.

Technology transfers have been such that Brazilian industry is a full partner in the project. The consoles, totalling more than 100, the secondary and approach radars, and the telecommunications and launching aids



Map showing the full extent of the Brazilian integrated air defence/ATC radar network when the Siscea programme is completed. The six air defence zones, with headquarters in Belem, Recife, Rio de Janeiro, São Paulo, Porto Alegre and Brasília are served mostly by LP-23M surveillance radars in the north of the country and TRS-2230 3D radars in the south



facilities were manufactured in Brazil with Thomson-CSF partnership. Brazilian contractors involved in the project include ESCA (Engenharia de Sistemas de Controle e Automatacao) SA, ELEBRA Controles SA, and Tecnasa Eletronica Profissional SA.

The Brazilian President manages the country's national security with the help of a National Security Council and the respective Service chiefs. There is no overall ministry responsible for defence matters, and it should be remembered that the Brazilian constitution prohibits its armed forces from attempting offensive operations. The strike/interceptor force of the Brazilian Air Force consists mainly of Northrop F-5E aircraft and Mirage IIIEBR, it is understood that both types are being upgraded. Brazil is also acquiring

more refurbished airframes of these models. Seventy-nine Embraer AMX fighters have been ordered with the first of these having been delivered. It is likely that further batches will be ordered to bring the overall total to 150. In addition Brazil operates a large COIN aircraft group with over 100 aircraft of various types. Embraer is developing a light fighter/combat trainer as an eventual replacement for some of these planes.

For ground-based air defence the Army deploys a small number of mobile Marder-mounted Roland SAM systems, 12 FILA systems, a variety of anti-aircraft guns with locally designed fire control systems. The Brazilian Army is currently undergoing a five-year modernisation programme in deployment and equipment which is designed to last until 1992.

## CANADA

The air defence of Canada is inextricably tied in with that of the United States, and the 1985 North American Air Defense Modernization (NAADM) accord between the two countries underlines the joint requirements. After the Canadian national elections in November 1988 the two countries have drawn even closer economically by a free trade agreement which will eventually abolish import and export controls between them.

A White Paper produced in June 1987, entitled *Challenge and Commitment*, outlined Canadian defence policy for the rest of the century and emphasised the basic tenet that the country's defence policy "will continue to be based on a strategy of collective security provided by the North Atlantic Treaty Organisation, including the continental defence partnership with the United States. Canadian forces are committed to the direct defence of Canada, the collective defence of North America and to peacekeeping." In May 1991 it was decided by the Canadian and US governments to renew the North American Aerospace Defence Command (NORAD) agreement for a further five years.

The basic NAADM project consists of: a new North Warning System (NWS) to replace the elderly DEW line, including new radar sites in Canada; the OTH-B sites in the USA and the use of USAF AWACS aircraft. This last point included the setting up of dispersed operating bases for the E-3s, and the provision of forward operating locations for interceptor and tanker aircraft when "in the judgement of the Canadian Government the international situation so warranted." The NAADM programme is funded jointly by Canada and the United States.

The new NWS radars are being positioned in Alaska, North Canada and down the Labrador coast, and consist of both long-range AN/FPS-117 and short-range gap-filler AN/FPS-124 surveillance systems. Installation of the former was completed in December 1989. Details of the system and its present status are contained in the relevant entry under the United States. Canada is responsible for the project management, system integration, new facility design and construction, operation and maintenance of the

system and is also supplying the complex communications network of NWS. In Canada, CANAC/Microtel received a \$268 million contract in 1986 for the creation of the communication facilities. These connect ground terminals at each of the radar sites with two large terminals serving the North American Air Defence System's Regional Operations Control Centre and a short-range radar development site, all located in North Bay, Ontario. CANAC/Microtel is supplying project management, system integration, design and engineering, satellite ground terminal equipment, network management systems equipment, on-site communications equipment for each of the Canadian radar sites (47 in all), system testing, mobile satellite ground terminals during the construction phase, operation and maintenance of the NWS communications system until 1992, documentation to support design and maintenance of the NWS.

Canada is also procuring a new Low Level Air Defence (LLAD) system for the 1990s, the cost of which will exceed C\$1 billion. The project is a most ambitious plan to equip Canadian armed forces with the Martin-Marietta/Oerlikon developed ADATS, the Contraves Skyguard fire control system and the Oerlikon-Contraves GDF-005 twin-barrel 35 mm anti-aircraft gun. By late 1990 the Canadian Armed Forces had taken delivery of all of the Skyguard fire control systems, the twin 35 mm towed anti-aircraft gun systems, and six of the ADATS systems mounted on a modified M113 series armoured personnel carrier chassis.

Canada is most unusual in that its defence forces are completely unified with no distinct services as such. The strike/interceptor part of the air force segment consists of CF-18 aircraft of which three squadrons are based in Germany as part of the NATO force. However, in September 1991 a new defence policy was announced whereby Canada will close its two European bases and withdraw all but 1100 of its troops from Germany by 1995. The Canadian Air Command will be reduced to four operational CF-18 squadrons in the air defence role. The current strength of the CF-18 force is 135 aircraft, equipped with AIM-7 Sparrow air-to-air missiles.

## CARIBBEAN AREA

To fill a gap in the air defence and air traffic control long-range surveillance radar coverage, the USAF is developing a radar network in the Caribbean basin to provide an enhanced capability to US Atlantic and Southern commands. Under Project 3159 (Caribbean Basin Radar Network) the USAF plans to erect the radars at various locations. Eight sites have been planned. The USAF is buying the systems and operating them, and will share data with the host countries. Bids were requested for the radar systems and the Westinghouse AN/TPS-70 was selected. Each site will also include long-range communications, ground-to-air communications, operations control and maintenance facilities. The first system has been

installed in Panama and is operational. The second site in the Dominican Republic, is also operational. Agreements for future sites have been signed with Colombia and Honduras, with the former agreeing to two sites. Other sites are planned in Costa Rica, the Cayman Islands and Venezuela.

The radar sites pass information to the Southern Region Operations Center in Panama, and its northern counterpart at Key West, Florida. These two centres provide automatic system-level tracking and identification for up to 16 radars in the network. An area 2048 nm<sup>2</sup> can be displayed covering the whole Caribbean area.

## CHINA, PEOPLE'S REPUBLIC

The armed forces of the People's Republic of China are nominally under the control of a National Defence Council of approximately 100 members, but for all practical purposes authority is vested in the Communist Party Central Committee, with central direction provided by its military commission. Despite this central authority a considerable amount of autonomy is exercised by individual area military commanders. A separate Defence Command is responsible for all aspects of air defence.

Very few details of Chinese air defence systems have been released but there are a number of statistics regarding their size. Until comparatively recently the Chinese were reported to have more than 100 surface-to-air

missile battalions in service and about 16 000 AA guns of various types. The Chinese Air Force operates over 5000 combat aircraft, of which approximately 4000 are interceptors (mainly of marginal effectiveness). Associated with these aircraft are about 1500 air defence radars, but little is known of the detailed employment of these systems other than the network provides airspace surveillance and control, and an early warning system for the detection of hostile aircraft. The geographical disposition of these radars is also not known, although many are undoubtedly dispersed along the borders with the Soviet Union and Vietnam.

Most of the radars are Soviet systems originally built under licence, or

more recent developments of these equipments. From the information available it seems that the majority of the systems are of the types evolved in the 1960s using 2D radars with heightfinders to provide full coverage. It is also probable that the country's air traffic control is integrated with the air defence network to give a co-ordinated approach. The most recent information, however, suggests that the country's defences are being substantially, albeit slowly, modernised. New radars are being designed including 3D planar array systems and improved versions of the SA-2 'Guideline' missiles, which the Chinese acquired originally from the Soviet Union and built as the HQ-1, are being produced as the HQ-2B/J. Despite this, the overall air defence network appears to be subject to major weaknesses, such as outmoded command, control and communications systems. Certainly China lacks a central and computerised air defence system, and responsibility for airspace control appears to rest largely with local area headquarters.

It is understood that in the mid-1980s a major French company supplied six long-range radars, three terminal area radars and control centres for airspace management of the Shanghai/Beijing region. Although there has been no official confirmation of this it seems fairly certain that China is manufacturing Western-style radars under licence, as well as being engaged in an indigenous surveillance radar development programme. Certainly a very large phased-array radar has appeared in the west of the country, presumably as part of the missile warning system. China has also stated that an OTH radar programme is being implemented, although the technical

problems and requirements of this type of radar make it appear more of a 'paper exercise' than an actual programme.

In proportion to size and population the current defence budget of the People's Republic of China is very small, less than one per cent of the gross national budget. According to Western analysts, China has cut its expenditure on defence by more than 50 per cent and its defence personnel by 25 per cent over the past decade. Spending levels are expected to decline still further as the country struggles against rising inflation and tight budget reductions. This will affect both the procurement of new equipment and the modernisation of existing weapons and systems.

The territory is so vast that a completely integrated air defence system would take many years, and an immense sum of money, to implement. Implementation of new air defence systems will undoubtedly be concentrated in the major areas of population, and to safeguard military targets. The general impression, however, is that spending on the more sophisticated items of defence is of a low priority compared to more urgent economic reforms, and that China is content for the moment to rely on its large conventional forces for protection. The confrontations and the subsequent repression, resulting from the incidents in Tiananmen Square, Beijing, have not helped China's cause abroad. A number of proposed defence acquisitions, particularly from the United States, have been 'frozen' and these are unlikely to be resumed until there is some indication of a change in the attitude of the Chinese Government.

## DENMARK

As part of NATO, Denmark's air defence system is fully integrated into NADGE (see NATO entry). As part of the NATO updating programme, two Marconi Martello S723 three-dimensional radars have been installed in Denmark, one of which is sited in the Faroes and the other on Bornholm in the Baltic. In addition Denmark and Norway, funded by NATO, have awarded contracts to Hughes Aircraft Company for an automated command and control information system for NATO's northern Europe command. The system was operational in 1989.

To improve detection of low-flying intruders a Coastal Radar Integration System (CRIS) was instituted in 1984 to link data from the Danish radars surveying the Kattegat and Western Baltic. In mid-1986 THORN EMI Electronics of the UK installed this coastal radar integration system in Denmark to feed information from the coastal radar network to the Danish elements of NADGE.

The Royal Danish Air Force operates a number of fighter/ground attack squadrons equipped with F-16A and F-35 Draken aircraft and a fighter/reconnaissance squadron with RF-35 Drakens. It also intends to retire and replace the Drakens with about 12 more F-16s in the long-term. An Air Defence Group is equipped with Improved HAWK batteries.

In April 1991 it was announced that Danish defence spending is to be reduced. The 1990 budget of Dkr14 billion (\$2.1 billion) was reduced by Dkr100 million for 1991 and will be reduced by Dkr300 million in 1992. One Draken squadron is being lost and a decision will be taken in 1992 whether to scrap the second Draken squadron and replace them with a squadron of new F-16s.

## EGYPT

Egypt has four armed services, one of which is dedicated to air defence. As a result of a somewhat chequered background in dealing for some years with the Soviet Union and later with various nations, Egypt's inventory comprises an extremely varied selection of hardware.

During the early 1980s four General Electric AN/TPS-59 and eight Westinghouse AN/TPS-63 air defence radars were delivered at a cost of some \$154 million. In addition 12 AN/TSQ-143 mobile automated operations centres, which interface with the radars, were provided for operation of HAWK missile batteries. Each operations centre has four OJ-560 display consoles, two main computers, 12 high-density microprocessors and an audio/video recorder that files all track data, displays and operator actions. These are now fully operational, with eight centres linked to the AN/TPS-63 radars and four linked to the AN/TPS-59s. In mid-1986 Egypt signed an agreement with Westinghouse to co-produce the AN/TPS-63 system. The deal was stated to be worth over \$190 million over seven years and covers the joint production of 34 radars by Westinghouse and Benha Electronics of Egypt. The first of these was delivered in December 1988 with an undisclosed number of the remaining sets having been delivered since.

In December 1983 Hughes Aircraft Company received a \$210 million contract for the first phase of a new Egyptian national air defence system which was intended to integrate all existing radars, missiles batteries, air bases and command centres into an automated command and control system. In late 1987 on-site testing of this phase began and subsequently Hughes has received another \$159 million to further expand the system. This includes additional command and control sites, operational software, control displays, large screen displays and computers.

The complete network enables detection and monitoring of unidentified aircraft approaching the borders and fast initiation of defensive measures, including the use of fighter interceptors and missile batteries. Egypt has also taken delivery of five Grumman E-2C Hawkeye early warning aircraft equipped with AN/APS-138 series radars, which form part of the network to detect low level aircraft at long-range.

The overall air defence system, known as Program 776, is scheduled to be operational by 1992/93. Hughes had received contracts worth about \$500 million, by mid-1991.

The automated system includes a variety of fixed and mobile units, some of which are up to 25 years old. They were manufactured in UK, USA, France and the Soviet Union, some of the older radars are being modernised. The computer software required by Program 776 is a highly complex system to cope with the separate interface needed by each system.

With the move away from Soviet equipment to Western systems (largely American and French), Egypt operates a mixture of both East and West. The split air defence system means that the Air Defence Command operates a mixture of MiG-21 'Fishbeds', Mirage 5SDEs, Shenyang F-7s and F-16A/F-16Cs, while the Air Force operates fighter/ground attack F-4Es, MiG-17 'Frescos', Shenyang F-6s, Alpha Jets, Mirage 5E2s and Mirage 5SDRs. SAMs include a large number of SA-2, SA-3, SA-6, Crotale, Chapparral, Improved HAWK, and Skyguard/Sparrow batteries. These last missile systems are made under licence in Egypt and are known as Amoun. The Army uses the Sakr Eye and SA-7 manportable missiles.



## FINLAND

In 1989 the Thomson-CSF TRS 2215D radar was chosen as the long-range component in the new Finnish air defence system. The full package, under a \$375 million allocation in the defence budget, includes 10 long-range radars, secondary radars, equipment to meet civil aviation requirements and a short-range radar-based missile system to meet the country's low level air defence requirements. The Finnish air surveillance system has also been enhanced by the acquisition of Siemens Plessey Watchman air traffic control equipment. The missile system is the Crotale NG (*Nouvelle Génération*) mounted on SISU XA-180 (6 × 6) APC chassis with deliveries commencing 1991 and lasting for two to three years. The missile used is the VT-1 which was designed by Vought LTV.

The fighter segment of the Finnish Air Force is equipped with about 75 aircraft; 41 survivors of 6 J-35B, 6 J-35FS and 32 J-35S Drakens and 25 survivors of 28 MiG-21bis 'Fishbed N'. Some 40 BAe Hawk trainers are also part of the force and these can be converted quickly to the ground attack role. SAM systems include the SA-3, SA-7, SA-14 and SA-16.

In the 1992 fiscal year budget the Finnish MoD submitted a request for the purchase of new aircraft to replace the Drakens and MiG-21s. Aircraft currently under evaluation include the F/A-18, F-16, Mirage 2000-5 and the JAS-39 Gripen. A decision is scheduled for mid-1992.

It must be remembered that, under the 1947 Paris Peace Treaty and the Finno-Soviet Friendship, Co-operation and Mutual Assistance (FMCA) treaty agreed in 1948, certain restrictions were placed on the size of the Finnish Armed Forces. Although no restrictions were placed on the defence of the country, the latter treaty stipulated that Finland will not allow its territory to be used in an attack on the Soviet Union. It was also agreed that Finland would be allowed only 60 operational fighter aircraft, a maximum army strength of 34 000 and a navy of 4500 personnel. However in September 1990 Finland said that, with the exception of the ban on nuclear weapons, the last remaining stipulations of the treaty limiting its armed forces had lost their meaning. Consequently, the Soviet Union and the United Kingdom were informed that Finland interprets Section III of the Paris Treaty in a new way.

## FRANCE

Although part of the NATO alliance, France is not a member of the integrated military structure. Since General de Gaulle took France out of the alliance in 1966, the country has had a chequered history of co-operation with NATO, although it has always been committed to the defence of Western Europe. However, during the past two years France has been extending its involvement with NATO, and although French forces will not come under the direct command of the NATO supreme commander in the event of hostilities, they will obviously co-operate to the fullest extent. This, however, does mean that much of the French air defence organisation is set up on national grounds as is evidenced in the STRIDA network outlined below, although STRIDA is interlocked with both NADGE and the United Kingdom's UKADGE.

As with many countries of Western Europe, France is reviewing its defence budget now that the 'Cold War' is apparently over. With the future of NATO somewhat cloudy and uncertain, and the collapse of the Warsaw Pact, France is considering a number of options in the air defence segment. The military budget for 1991 was fixed at FFfr195.4 billion (\$33.6 billion), including FFfr103.1 billion for equipment programmes and FFfr92.3 billion for operational costs. It has been decided to hold 1992 defence spending to the same level. A five-year plan for defence is also being formulated.

The Strategic Air Command of the French Air Force is the nuclear strike force, and is designed to carry the ASMP tactical nuclear stand-off missile. The force will eventually consist of 18 Mirage IVs, 75 Mirage 2000Ns, plus 24 Super Etendards from the Naval Aviation. The Air Defence Command has approximately 300 Mirage F-1C, 2000C and IIIC interceptor aircraft operating within the STRIDA air defence system. The Tactical Command operates a variety of Mirage aircraft and about 45 Jaguars. Over 300 Mirage 2000s have been ordered to replace the older aircraft. France has also ordered four Boeing E-3 AWACS aircraft, the first aircraft being delivered in October 1990, and all four being scheduled for delivery by November 1991. The complete fleet will eventually be phased in with the STRIDA network and the overall NATO command. France is also committed to the Rafale fighter which is likely to enter service in the latter half of the 1990s.



VISU IV consoles produced by the Sintra subsidiary of Thomson-CSF for the STRIDA air defence system



A STRIDA air defence reporting centre and communications node collocated with a 3D radar in the Alps

### STRIDA

STRIDA (*Système de Traitement et de Représentation des Informations de Défense Aérienne*) is the French national air defence data handling system. It consists of a network of stations covering French territory, with the following main functions:

- (a) detection and identification of aircraft in French airspace
- (b) threat evaluation and dissemination of early warnings. The air situation is centralised and synthesised in the air defence operational centre (ADOC)
- (c) updating of active means (aircraft and missiles) status in every sector operational centre (SOC)
- (d) weapons selection, engagement and automatic interceptor guidance
- (e) aircraft recovery to air bases
- (f) control of military operational and training flights
- (g) co-ordination with the air traffic control system to ensure identification and spacing of operational military flights with general air traffic
- (h) progressive integration of the information reported by air base radars for improving the low altitude coverage.

STRIDA is organised around a network of about 50 radar installations (10 air defence radars, 10 civil radar stations and 30 low altitude radar stations), and seven main operational command and control centres (CDCs). Of these four are also local centres of operations located at Drachenbronn, Lyon, Mont-de-Marsan and Tours, while three others, at Contrexeville, Doullens and Nice, are secondary centres.

Each local control centre has a 3D Palmier or a 2D Satrape radar, as well as a backup 23 cm 2D radar. STRIDA is organised around two 8Mb IBM 4381 computers at each centre which can each handle 2.8 MIPS (millions of instructions per second). With the existing structure, each centre can receive information from 50 different radar stations, process data from up to 30 of them, and track 508 primary targets. It is hoped that eventually they will be able to cope with over 1000 traces. One computer is used for general air defence and the other for command and control. A third IBM 4341 or 4381 dyadic processor is used as an interface between the radars and the two other 4381 computers to provide readouts of findings. The Lyon control centre is equipped with an IBM 3090 dyadic processor which is considerably more powerful than the previous computers. STRIDA is linked to the different systems and identification is automatic. The system is linked to the French CAUTRA civil air traffic control system, the allied air defence networks including NADGE, UKADGE, the 412L network, Combat

Grande of Spain and the SHAPE early warning. The system is also linked with the low level approach centres (CLAs), with HAWK regiment co-ordination centres and the Mirage 2000 interceptor aircraft. Links are planned for STRIDA with air force stations and fighter squadrons.

Information is displayed on 20-30 Visu III consoles supplied by Thomson-CSF. These have been replaced at some centres by Visu IV units which are more powerful. The STID system for processing and transmitting information, using a local network with server which will communicate with the host, was due to be completed by the end of 1991. Transmission is by fibre optic cabling. The first version of STID used for aerial surveillance will display either total information or information of specific interest.

**Status:** A continuous programme of improvements and upgrading for both hardware and software has been carried out since the first stations became operational in 1963. Medium and high level coverage has been achieved and the low level STRAPP system has been completed. The planned modernisation of the control centres will include the replacement of the air defence radars with Thomson-CSF TRS 22XX 3D long-range selectronic scanning systems which are due for delivery in the early to mid-1990s, and

the mobile TRS 2215 radars currently being evaluated at Istres. In addition it is intended to adapt the 23 cm radars to give an electronic countermeasure capability and to move them to air force bases so that they can supplement existing civil radar installations. As part of the 'Army 2000' restructuring programme, the local control centres are to be replaced by two control centres with zones of activity.

#### SAAM Air Defence Systems

Thomson-CSF is developing a range of anti-missile weapon systems. These are based on the Arabel multi-purpose scanning radar and the Aerospatiale vertically launched Aster missile family. Full details of these are given under International in the *Static and Towed Surface-to-Air Missile Systems* section.

**Contractor:** Thomson-CSF, Division Systèmes Défense et Contrôle, 18 avenue du Marechal Juin, F-9253 Meudon-la-Forêt Cedex, France.

## GERMANY

As part of NATO, the forces of Germany are fully committed to the alliance, and the western part of the country is covered by the air defence networks of NADGE and GEADGE (see below). Since the defence forces were re-activated during the period of occupation after the Second World War they can only operate as a part of the overall NATO force. The German Air Force has undergone a major re-equipment programme which was to replace the obsolete F-104 fighter/ground attack aircraft with Panavia Tornados. Most of the latter have now been delivered. The force also operates about 175 close-support Alpha Jet aircraft. Air defence equipment includes three air defence regiments with Roland II SAMs, Patriot SAMs, Improved HAWK and manportable Redeye/Stinger systems.

#### GEADGE

GEADGE is the acronym for German Air Defence Ground Environment and is the network for the southern part of Germany. The system, for which Hughes Aircraft Company was nominated the prime contractor in 1979 under a contract worth more than \$150 million, replaced an older radar network operated by the German Air Force. The system integrates new and existing long-range surveillance radars into a single network based on four centralised command centres, and is now fully operational. It embraces manned and unmanned fixed and transportable radar systems.

GEADGE now receives data directly from E-3A AWACS early warning aircraft. The southern part of Germany was not included in the original NADGE system but GEADGE fills the gap left in that system and interconnects directly with it. In addition to fixed and transportable gap-filler radars, the new system uses two of four new permanently located radars known by the manufacturer's name of HADR (Hughes Air Defence Radar). This is an advanced 3D, multi-role system which will automatically detect, classify and report targets intruding into its coverage.

In the GEADGE system, Hughes has also supplied HMP-116 mini-computers, H-5118M central computers, and HMD-22 display and control consoles, as well as being responsible for software, installation and integration. The HMD-22 consoles are built under licence by AEG and the communications equipment for the system has been supplied by Tekade.

More recently, the GE AN/FPS-117 long-range radar has been selected for NATO use. A contract for three systems has been awarded by Germany for NATO infrastructure application, although one additional FPS-117 system was installed in West Berlin some time ago, to replace an obsolete radar.

The GEADGE system is approaching obsolescence, and with the delays in the ACCS programme (see NATO entry this section), Germany, the Netherlands and Belgium are considering a Central Region Initial ACCS Programme (CRIAP) to upgrade their present air defence ground environment systems.

#### TMLD Low Level Reporting and Control System

The air defence of Germany is intimately bound up with the overall NATO Air Defence Ground Environment (NADGE) system of radars, communications and data processing and control centres, and to varying degrees with systems employed by allied nations present in Europe, such as the American 407L air weapons control system. However, because of limitations in the low level cover of parts of the former systems and because the AFCENT sector of the Central European NATO area is particularly subject to the threat of low flying surprise attacks, the Luftwaffe has set up



A captain monitors the air traffic over the southern portion of Germany at a GEADGE site

the TMLD (*Tiefflieger-Melde-und-Leitdienst*) low level reporting service, additional and supplementary to the other radars.

This is part of the combat operational system of air defence and is designed particularly for the monitoring of low level airspace. The TMLD radars are located in the area near the border, the individual sites being chosen to ensure continuous surveillance. When the radar detects a target, the information is converted into data messages and immediately transmitted to the low level reporting centres, TMLZ (*Tiefflieger-Melde-und-Leitzentralen*), and on to the user. The whole TMLD is completely mobile so that changing tactical and operational circumstances can be accommodated. The main tasks of the TMLD are:

- (a) monitoring the lower levels of airspace in selected areas
- (b) processing the low level air situation in the control centres (TMLZ) and passing the information on to the air defence control centres (for example NADGE, GEADGE)
- (c) preliminary warning and target forecasting for HAWK SAM units
- (d) control of air operations.

The TMLD units are combined into two sections, and are employed in the 2 ATAF and 4 ATAF areas. In each case they come under the authority of the commander of a Type B signals regiment. It is planned to assign them as a NATO command force. The main elements of such a unit are:

- (a) a radar crew to operate the radar equipment
- (b) an evaluation crew to man the control centre
- (c) a radio relay crew for setting up communications links
- (d) a maintenance crew for the maintenance and repair of equipment.

In peacetime the TMLD mainly limits its activities to monitoring the area in the immediate vicinity of the border, in a quasi-static role.

At other times, however, monitoring of airspace must be extended to a greater area, making use of the system's mobility and flexibility. In this it will be supported by the Army's AAD command and control systems, which will be employed in monitoring the airspace over the combat area.





A Siemens MPDR-30 radar of Germany's low level air defence system deployed in the field

The principal hardware used in the TMLD system comprises: MPDR 30/1 mobile pulsed Doppler radars; TM control centre; CRC TM display unit; and a radio link set. The radar consists of two 5 ton trucks, each with a

1½ ton trailer containing a generator, with one truck serving as an equipment carrier and the other as the antenna carrier. In the TM centre all the information provided by all the radar equipment within one sector is processed and displayed. Linked users include the NADGE/GEADGE air defence control centres and Improved HAWK SAM batteries.

#### Operation

Information on air targets supplied by the TM radar is converted into messages for transmission to the TMLZ. The data transmitted contains the positions of the target as X/Y co-ordinates and the target identification. Two operating modes are planned for the preparation of this information; automatic and semi-automatic.

Automatic operation is regarded as the normal mode for peace time. Targets detected are automatically evaluated on the basis of whether or not they emit a valid IFF/SIF code and they are reported accordingly. In addition, the operator in the radar truck (acting on instructions from the control centre) can insert further symbols manually in order to give prominence to certain targets of particular significance.

Semi-automatic operation is of special importance when automatic operation with the radar signal processor is not possible, for technical or tactical reasons. In this mode the operator can mark targets identified on the radar display with the aid of a rolling ball, using symbols that he can superimpose on the target blip. Transmission of targets to the TMLZ or the user is again performed automatically. For this purpose various types of symbol are available, to each of which a particular meaning is assigned to assist the responsible air defence officer in reaching decisions.

**Status:** The system has been fully operational since 1977.

**Manufacturer:** Siemens AG, Radio and Radar Systems Division, Landshuterstr.26, D-8044 Unterschleissheim, Federal Republic of Germany.

## ICELAND

The first phase of an interim air defence system, which began operations in July 1988, has closed the gap that existed between defence systems in the United Kingdom and European NATO countries with the Joint Surveillance System in the USA and Canada. The system incorporates the two Bendix AN/FPS-93 ground radars used in the earlier system, positioned at Rockville and Stokksnes in the south-west and south-east corners of Iceland respectively, to detect and monitor all traffic in the area around Iceland, and also has extended surveillance coverage through links with US and NATO E-3 AWACS early warning aircraft. Two northern radar/communications sites at the north-east and north-west corners are now operational. Operated by the USAF, the new system ties in directly with the combined US/Canadian facilities at Griffiss AFB, New York and North Bay, Ontario. It replaces a manual system which was more than 30 years old.

The first phase, which is an interim system, provided by Hughes Aircraft Company, incorporates two computer networks, one of which acts as a 'hot' spare and can be switched in to take over from the primary. A total of 12 operator consoles, each having a 19 in monochrome CRT and a smaller screen for data displays, are provided. Digitised radar tracking data from the AN/FPS-93 systems plus information from heightfinding radars is presented. Another part of the interim system, the Iceland Command and Control Enhancement (ICCE), became operational in 1989 and will improve links between ground command and control and the AWACS aircraft.

The next stage of the Iceland Air Defence System (IADS) includes four GE Aerospace AN/FPS-117 radars installed at the four corners of the

island at Rockville, Bolungarvik, Gunnolfvikursfjall and HoIn. The delivery schedule for these four radars was for the first to be installed in June 1991 and be operational by October 1991. The next two were due to follow at intervals of two months with the last of the four entering service in March 1992. Eight consortia submitted bids to develop IADS and in June 1990 Hughes Aircraft Company was awarded a \$77 million contract. The system will be based on open architecture and allows for future expansion when required. It will be based on the Hughes AMD-44 workstations and implemented with Ada software language, using DEC computers. IADS will be the first major air defence system to use the Ada high programming language. New hardened main and alternate control and reporting centres (CRC) are being developed, the main centre being located at Keflavik to replace the ICEROCC. Extensive communications facilities are incorporated. Each radar will be linked via two redundant paths to the CRC, using the fibre optic cables as the primary links, and microwave line-of-sight communications as backup. The CRC will also receive data from airborne and maritime sensors to provide an overall air-surface picture. Testing of the complete system was scheduled to begin in mid-1994, with acceptance in early 1995 and operational at the end of 1995.

Iceland itself is a member country of NATO and as such has NATO airfields and radar sites on its territory. It does not, however, have any defence forces of its own other than a Coast Guard and a limited number of paramilitary security personnel.

## INDIA

The existing Indian IADGES (Indian Air Defence Ground Environment System) is understood to consist of a miscellaneous assembly of radars of varying origin, reflecting India's changing international associations and allegiances over the past 40 years. This includes UK, French, Soviet and Italian systems and possibly other types. In the 1970s the system was installed along the Indian northern and western borders (with China and Pakistan), and a communications system for use in the air defence of a limited area along the northern border built with American equipment. In addition, at least 24 long- and medium-range radars of Italian design were installed, ostensibly for ATC purposes, but clearly so that data from some could be used for air defence. Most of these radars are D-band equipments, eight being the ATCR-2 and the remainder ATCR-4Ts. Licensed production of the latter was carried out in India by Bharat Electronics.

In 1984 Thomson-CSF announced a contract to supply four TRS-2215D three-dimensional radar stations to India, and the construction under licence of at least five more. India is now developing an indigenous air defence radar industry largely based on co-operation between Thomson-CSF and Bharat Electronics.

In November 1990 it was reported that India had flight tested an airborne early warning aircraft, known as ASWACS (Airborne Surveillance and Warning Control System). No details of the aircraft and its sensors have been released and no information on its progress has been made available. It was stated that the flight tests were successful and the aircraft was indigenously built.

India has very considerable numbers of Soviet fighter aircraft and missile systems. The latter includes SA-2, SA-3, SA-6, SA-7, SA-8, SA-9, SA-11

and Tigercat surface-to-air missiles. These missiles rely upon the appropriate Soviet and Western fire control radar, such as Long Blow, Straight Flush and so on, for guidance.

A very ambitious programme, aimed at self-sufficiency in missile design and production, has been initiated by India and the first results are now becoming evident. In the surface-to-air field two weapons are in development: the Akash which is a long-range SAM, and the Trishul which is a short-range low level SAM system for the army. The Prithvi 250 km range surface-to-surface missile has been successfully tested. Both the Trishul and the Prithvi are expected to be in service in the near future. An

intermediate range ballistic missile (IRBM), called Agni, with a reported range of about 2500 km, has also been tested successfully.

The Indian Air Force is divided into a number of regional commands to cover a vast country of some three and a quarter million square kilometres. The battle order reflects the split loyalties of India between east and west. The 20 air defence squadrons use some 400 aircraft, including MiG-21s, MiG-23s and MiG-29s. The fighter/interceptor and fighter/ground attack force consists of 31 squadrons equipped with Mirage 2000s, Jaguars, MiG-23s and MiG-27s. More MiG-29s are on order to replace the MiG-23s and licensed production of the MiG-27 is underway.

## INDONESIA

Considerable modernisation of Indonesia's air defence network has taken place during the 1980s. Thomson-CSF of France has been heavily involved in this updating and originally supplied two TRS-2215D radar systems, followed by 12 TRS-2230Ds. By the mid-1980s Thomson-CSF had provided four centres for air traffic control purposes, and had installed several TA 10 or TA 23 primary radars, RS 770 or RS 870 secondary radars and 10 regional control centres. These systems could also be used to augment the air defence network. More recently Indonesia decided to update its air defence for the central area, and instituted a competition to which several companies responded. In October 1989 it was announced that Siemens Plessey Radar had been awarded a contract for an undisclosed amount to

carry out a major extension of the Indonesian air defence system. This involves the supply of a number of 3D radar sensors with data display and handling systems. Thomson-CSF has also announced its involvement in developing an integrated airspace coverage system in co-operation with local industry and installed TRS-3400S maritime surveillance radars in the Strait of Malacca.

The Indonesian Air Force is relatively small in numbers. It operates two attack squadrons with A-4Es and an interceptor squadron with F-5Es. A small number of F-16As are being delivered. Rapier SAM systems are in use with the army.

## ISRAEL

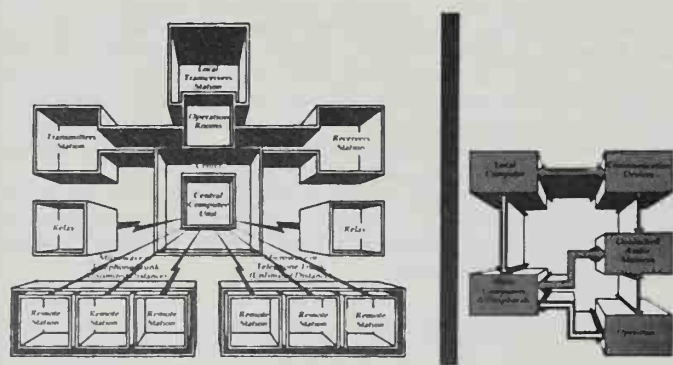
A computer-controlled air defence system has been installed in Israel but no official details have been made public, and indeed no official confirmation of its existence has ever been made. It appears to be generally accepted that Hughes Aircraft Company was awarded the contract after completing a study for the new system, it is also understood that the system is based on main control centres situated near Tel Aviv and in the Western Negev. There are probably subsidiary centres elsewhere, and the existence of a tactical operations centre with a PPI display of the entire Israeli airspace for viewing by the Cabinet has been claimed. The complete system has been in operation since the mid-1970s.

It is believed that there are many similarities with the USAF 407L tactical command and control system, and it has been reported that Hughes 4118

digital computers, as used in the 407L, are employed for data processing. Sensors are understood to include two Westinghouse AN/TPS-43 3D radars and several AN/FPS-100 systems. In addition there are almost certainly other radars of UK, French and Israeli design which have been incorporated in the system. Elta Electronics manufactures a range of mobile and static surveillance radars based on the original EL/M-2205 design, it would appear very probable that some of these are incorporated in the system, perhaps as replacements for the AN/FPS-100 equipments which would now be rather obsolete. For the airborne element, four Grumman E-2C early warning aircraft were delivered during the late 1970s, each equipped with AN/APS-125 radar. This may have been updated with the later variant, the AN/APS-138. Grumman also carried out a contract to make the E-2C data link compatible with the Israeli air defence network to enable the exchange of data between ground and air sensors, as well as integrating the AEW element into the overall system.

In the early 1980s a major communications control system for air defence sites, known as the MCCA-800, was supplied by Electronics Corporation of Israel in co-operation with Elbit Computers. Alternatively known as ACCESS, the system provides each one of a large group of operators with fast and reliable access to up to 1000 communication devices located in the control centre vicinity or in remote communications stations.

The Israeli defence forces are unified, with their cost largely underwritten by the United States which contributes a large amount of foreign aid to the country, either in the form of equipment or in financial terms. The air force segment operates mainly American-built aircraft with F-15A/C, F-4E, Kfir C7 and F-16A/C fighters, specialist F-4E and F-16D air defence suppression aircraft, RF-4E reconnaissance aircraft and A-4H/N ground-attack aircraft. A further 30 F-16C and 30 F-16D are being delivered. For ground air defence some 15 SAM battalions with Improved HAWK are deployed whilst field units deploy static and mobile anti-aircraft guns, Chaparral SAMs and manportable Redeye and Stinger SAMs. Two Patriot fire units supplied during the Gulf War are to remain permanently in Israel, and at least two more batteries are being purchased.



System architecture (left) and block diagram (right) of the ACCESS system

## ITALY

The Italian national air defence system forms part of the NATO NADGE (see separate entry). The most recent development in that area has been the acquisition of two Hughes HR-3000 E/F-band 3D radars which were supplied by NATO to upgrade the cover in its southern flank, and the order of GE AN/FPS-117 D-band long-range radars. Much of the national air defence network is based on the Selenia RAT-31S radar which is operated by the Italian Air Force, both in its transportable role and in a mobile tactical form as part of the MRCS-403 command and control centre. A version of the RAT-31S, known as the RAT-31SL, has been developed

by Selenia in co-operation with Sperry (now part of the Unisys Corporation), and 10 of these systems were expected to be ordered by the Italian Air Force.

A new integrated command, control and telecommunications system, known as CATRIN, is in the development stage with operational deployment scheduled for 1993. It is primarily for battlefield use and is part of an overall modernisation programme for the Italian Army, from helicopter gunships to C<sup>3</sup>I systems. The system consists of three subsystems: a telecommunications network (SOTRIN), a surveillance/ground target



acquisition and fire control system (SARAO), and a low/very low air surveillance subsystem with tactical command and control of AA guns and aircraft (SOATCC).

The SOATCC subsystem comprises a radar network, a command and control system and an information/logistics network. The radar network uses both 3D and 2D sensors to identify low and very low flying targets. Using this data the command and control centres evaluate the threat, co-ordinate air defence, and control the airspace and missions of friendly aircraft.

The CATRIN project began in June 1987 when the Italian MoD commissioned a consortium of companies to produce the system. The

consortium consists of Aeritalia, Agusta, Italtel, Marconi, Italiana, Selenia and Telettra. A six-year programme is envisaged, with pre-prototype testing scheduled to take place in 1993.

As a member country of NATO, Italian forces form a substantial part of NATO's Southern Command. The Italian Air Force has been re-equipping with Tornado IDS, although for air defence it has a large number of F-104S Starfighters in service. For close air support a substantial number of the joint Italian/Brazilian AMX fighter aircraft are being procured. The main SAM batteries are equipped with Improved HAWK with procurement, by licensed production, of the Mistral and Patriot.

## JAPAN

The Japanese air defence system, BADGE (Base Air Defence Ground Environment), is a computerised air defence system which provides umbrella protection against air attack on the Japanese mainland. The system consists of radars which will automatically detect, track and identify airborne targets over Japan and the surrounding ocean, computers to process data and furnish information on weapon availability, and interception data. The system was built largely in Japan for the Japanese Self Defence Force, with Hughes Aircraft Company of the USA as the prime contractor, and it became operational in 1969. Much of the original equipment and system design was supplied by Hughes but most of the subsequent manufacture has been indigenous.

BADGE sites extend from the northernmost tip of Hokkaido to the southern extremity of Okinawa Island, and there are at least 28 fixed surveillance radar sites. Japanese airspace is divided into four air defence sectors with a direction centre for each.

In 1982 Japan initiated an extension programme known as BADGE-X, which was intended to increase its coverage and provide for the integration of the Japanese HAWK surface-to-air missile batteries with the existing defence systems. In early 1983 the NEC Corporation was selected as prime contractor to undertake this extension programme, with Hughes as a major subcontractor for systems design, management and licensing of hardware. There were five phases of this operation, although the precise order was not known:

- (a) updating and expanding BADGE to improve coverage
- (b) linking BADGE to the Patriot/Improved HAWK batteries, via the JAN/TSQ-51B distribution systems being built by the NEC Corporation under licence from Hughes
- (c) development of an airborne early warning system
- (d) further extension of BADGE to cover key areas such as Okinawa
- (e) replacement of the Bendix AN/FPS-20 and GE AN/FPS-6 radars with 3D systems.

Installation and construction of the extension programme commenced in 1985, with the first system installed at the HQ of the Middle Air Defence Force and the new BADGE system is now fully operational.

The BADGE system computers have all now been replaced and/or duplicated, and additional computers and peripheral equipment have been added. Older early warning and fighter radars have been replaced by modern 3D types. The equipment selected has the JASDF designation of J/FPS-2, but is also known as the F3D. It is produced by the NEC Corporation

and is understood to be based on a mobile radar known as the J/TDS-100, the first example being installed in 1979. The J/FPS-2 is an electronically scanned phased-array radar using mechanical rotation for azimuth scan and extensive ECCM facilities. The JASDF is believed to have at least seven of these systems in operation, plus a number of the mobile J/TDS-100 radars. It would appear that these radars are variants of the NEC NPG-880 or its mobile version, the NPM-510. The JASDF also operates the older J/FPS-1 air defence radars but these are being gradually replaced with nine new J/FPS-3 fixed 3D systems. The first of these radars was due to be installed at the Kyogasaki radar site in Kyoto by the end of 1991. The older J/FPS-1 radars will be replaced at the rate of one or two per year. Each of the new systems provides flexible detection and tracking with strong resistance to electronic countermeasures and anti-radiation missiles. In addition, research and development on a new indigenous produced radar to replace the J/FPS-2 systems is already well advanced.

It has been reported over the past few years that Japan had decided to purchase an over-the-horizon radar system (probably the Raytheon ROTHF) for installation on one of its Pacific islands. This has now been shelved because of geological problems and the diminished Soviet threat in the Pacific Ocean area.

In addition to the ground-based air defence system, Japan has acquired an airborne early warning force of eight E-2C aircraft, all of which are operational and feed information into the BADGE network. A further five E-2C aircraft have now been ordered. A planned order for four E-3J aircraft has been cancelled because of high unit cost involved in opening up the Boeing 707 production line. Instead the Japanese Defence Agency has decided to request a \$740 million budget for Patriot surface-to-air missile systems.

The Japanese armed forces are designated as Self Defence Forces to avoid any possibility of being thought of as offensive military arms. The Japanese Self Defence Force is equipped entirely with American aircraft which consists of F-15Js and F-4EJs for interceptor purposes. A modernisation programme to produce the F-4EJ Kai is underway. Development has started on a version of the F-16, known as the FS-X, which is intended to replace fighter/bomber aircraft. About 130 of the FS-X type are planned, although the development programme has been considerably delayed. The first Lockheed EP-3 electronic warfare data collection aircraft, built under licence by Kawasaki Heavy Industries, has now been delivered to the Japanese Maritime Self Defence Force.

## JORDAN

Jordan's air defence is based on F-5E and Mirage F-1CJ aircraft, and Improved HAWK SAMs supported by AA guns. The main command and control element is the Litton Data Systems AN/TSQ-73 air defence missile control and co-ordination centre. To augment its air defence network, Jordan tried to obtain mobile Improved HAWK batteries plus a number of modern American aircraft, but the request was blocked by opposition from the US Congress. Contracts were then signed with France for 12 (+ 8 options) Mirage 2000 aircraft and with the UK for 8 Tornados. However, faced with its worst economic crisis for more than a decade and the aftermath of the Gulf War (during which it supported Iraq) Jordan has had to

postpone several programmes including the foreign aid procurement of the Tornados and Mirages and the construction of a \$10.5 million satellite and radar station at the Red Sea port of Aqaba.

A number of radars of western origin, including five Westinghouse AN/TPS-63 equipments, are currently operational, and the Royal Jordanian Air Force has placed a contract with Marconi for a number of Martello 3D air defence radars. The contract also includes modernisation of existing radar facilities.

Redeye, SA-7, SA-8, SA-13 and SA-14 SAMs are in operational service, with Shorts Javelin manportable systems believed to have been delivered.

## KOREA, NORTH

North Korea has a comprehensive air defence system which has been radically upgraded during the past three years. Various reports during 1989 estimate that North Korea spends 20-25 per cent of its gross domestic product on armaments. The number of deployed SAM battalions has been expanded to cover the entire country, and the range, quality and type of radar coverage has been increased. This has resulted from a Soviet agreement to modernise what was an obsolete system in exchange for port privileges and overflight rights. MiG-23 fighters have been supplied, and more recently SA-5 'Gammon' SAMs have arrived. An estimate of total SAM force indicates a total of 1200 deployed (SA-2s, SA-3s and SA-5s), with a similar number in strategic storage. Additional air defence fighters have been delivered in the form of several batches of MiG-29 'Fulcrum-A' totalling 30 plus aircraft.

North Korea is believed to be the only country outside the USSR to have deployed the advanced Tin Shield early warning/GCI target acquisition

radar system. Depending upon its location, Tin Shield can provide coverage of large parts of South and North Korea. Barlock A GCI systems and Fan Song A missile control radars are also in use. Early warning, target acquisition and GCI radars are deployed in large underground bunker complexes consisting of an access tunnel, control room and crew quarters, protected by steel blast-proof doors and nuclear, biological and chemical filtration systems. The radar antennas are mounted on elevators which raise them to the surface when required.

The entire country comprises a single air defence district, controlled by the Korean People's Air Force (KPAF) with its headquarters in Pyongyang. The district is divided into three sector commands, although the defence of Pyongyang itself is believed to be provided by a special subsector. Each sector command consists of an HQ, air defence direction centre, early warning radar regiment, at least one fighter division, several SAM regiments, and one AA artillery division.

## KOREA, SOUTH

South Korea already possesses an air defence system which is primarily orientated along its northern border with North Korea and the coastal waters to the south-west, no details of this system have been made available.

A new overall air defence system to provide for target assignment, early warning and co-ordination of other air defence forces such as interceptors is being developed. Two variants of the Westinghouse AN/TPS-63 are currently employed, a dualised AN/TPS-65 version which combines two AN/TPS-63 radars in one system, and a dual-band version which combines the technology of the AN/TPS-43 and the AN/TPS-63. Five GE Aerospace AN/FPS-117 air defence radars are currently in operation and a further three have been ordered.

Improved HAWK surface-to-air missiles are being supplied and the country is also procuring the related AN/TSQ-73 system for command and control. Other SAM systems include the Nike-Hercules, Redeye, Stinger and Javelin. It is understood that a major reorganisation of South Korea's armed forces took place on 1 July 1990 when responsibility for most of the country's ground-based air defence assets was moved from the army to the air force.

The Air Force has four fighter squadrons of F-4D/E Phantoms, two of F-16C/D Fighting Falcons and 16 of F-5A/E. Additional aircraft are planned including a large number of F/A-18s to replace the F-4s and F-5s. It is believed that over 120 aircraft are planned with most of the production being under licence within South Korea. In addition the USAF maintains around 70 fighters (F-16C/D) in South Korea as part of its commitment to that country.

## KUWAIT

In the Summer of 1990 Kuwait was invaded and occupied by Iraq and was liberated by an allied force in early 1991. Before the invasion by Iraq, Kuwait had acquired a number of air defence radars, including the AN/TPS-32, AR-3D and TRS-2230 systems. In addition, an integrated air defence command and control system had been set up by Thomson-CSF, and low altitude defences had been modernised.

It is now apparent that the complete air defence infrastructure was either destroyed or captured by Iraq. Kuwait is currently endeavouring to replace its air defence network, although this is likely to take several years. As far as the Kuwait Air Force is concerned, the first of 40 F/A-18 Hornet strike fighters has now been delivered. The remaining 39 aircraft will be delivered over the next two years.

## LIBYA

Over a period of years companies from a number of countries, including the USA, UK, Italy and France have competed for the task of modernising the Libyan air defence network, but these efforts have been thwarted by political obstacles. With the almost total lack of contact between Libya and the Western countries, air defence is understood to be based on Soviet principles, and relies upon equipment from the same source. The Libyan Air Force interceptor force consists of some 275 aircraft, with 60 MiG-25 'Foxbat-A', 165 MiG-23 'Flogger-E', 50 MiG-21 and 37 Mirage F 1ED.

Libya has a separate Air Defence Command as part of the air force, with a command and control system known as SENEZH. No details are available, although it is likely that the radar network consists of a mixture of older French and Italian equipments, with the later systems being of Soviet origin. The armed forces operate a large number of Soviet surface-to-air missiles, equipped with their fire control radars, including the SA-2, SA-3, SA-5, SA-6, SA-7, SA-8, SA-9, SA-13, as well as the French Crotale system. The Army also uses SA-7 manportable SAMs as well as a wide variety of mobile and static anti-aircraft guns.

## MALAYSIA

With the withdrawal of the UK forces from the Far East in 1971, the Malaysian Government procured three Marconi S600 mobile radar units to meet the country's immediate needs and support the RAAF detachment of rotated F-18 aircraft through the base.

In the early 1980s Malaysia instituted the Malaysian Air Defence Ground Environment (MADGE) programme with Hughes Aircraft Company as the prime contractor. This system is now operational and provides air surveillance and identification services for civil and military aircraft in all airspace of interest to Malaysia. It uses modern data processing equipment, large screen displays, new communications and Hughes air

defence radars (HADR), used in conjunction with earlier existing radars, to provide target data for the entire country. Control of radar sensors, aircraft and other air defence assets is exercised from a number of control centres.

Malaysia is known to be considering an update of its air defence capability by the acquisition of a number of assets, including AWACS aircraft, new fighters, low level air defence radars, various surface-to-air missiles and low level air defence guns, although some of these plans have had to be shelved because of budgetary restraints. Malaysia has received Congressional authority to buy eight F-16 aircraft from the USA.



A Memorandum of Understanding for contracts worth \$1.7 billion was signed between the UK and Malaysia in 1989. Since that date the value of the pound sterling has risen substantially against the Malaysian dollar and has placed a few of the deals in jeopardy. However, the main contracts have been signed, including Martello radars from Marconi with other

improvements in MADGE, a tri-service C<sup>3</sup>I infrastructure with GEC's EASAMS systems engineering subsidiary and 28 BAe Hawk 100/200s. Currently the Malaysian fighter aircraft force consists of 15 F-5E/Fs, plus a fighter/ground attack force of 36 A-4s and 17 F-5Es.

## MOROCCO

A comprehensive air defence network was initiated in 1977 and is currently operational. The principal contractors were Westinghouse, Burroughs (now part of the Unisys Corporation) and Ford Aerospace under a contract assessed at about \$100 million. Westinghouse provided the primary radars and integrated the entire system while Burroughs supplied large scale B-6700 computers for processing tracks, ATC data, identification and plot extraction. Ford Aerospace provided the microwave communication links.

The complete system is based on eight AN/TPS-63 radars at early warning and coastal sites. A centralised command and control facility

directs Moroccan air defence aircraft, which are Mirage F-1CHs. These are complemented by Army anti-aircraft guns and Chaparral, Crotale and SA-7 missile systems.

In October 1991 it was reported that Westinghouse had been awarded a \$21 million contract to modernise Morocco's air traffic control system. The contract allows for various options such as surveillance radars, SSR systems and management systems. Although this is related to the civil network, the equipment to be supplied could be easily integrated into the defence infrastructure.

## NATO

The *raison d'être* for the NATO alliance over the past 40 years has been the threat of action by the Soviet Union and other Warsaw Pact countries. With the diminished threat from the Soviet Union and the scrapping of the Warsaw Pact, the members of the NATO alliance have been reviewing its status and future. A number of suggestions have been put forward, including a Rapid Reaction Force, the possibility of offering former Warsaw Pact countries associate membership and greater control of NATO by the European Community. The agreement between the Soviet Union and the West under the Conventional Forces in Europe (CFE) treaty has heralded drastic cuts in overall NATO forces. The effect on the air defence sector (NADGE) is not yet apparent but it appears increasingly unlikely that the Air Command and Control System (see later) will go ahead as planned.

The NATO Air Defence Ground Environment (NADGE) is a multinational programme involving 14 NATO countries (as far as funding and contracts are concerned) in the updating and co-ordination of the air defence systems of 10 European members of NATO, namely Norway, Denmark, Germany, Netherlands, Belgium, Italy, Greece, Turkey, Spain and Portugal. The British air defence network, UKADGE (see later entry), interfaces with NADGE. French participation is limited to use of, and contribution to, the reporting and control functions via STRIDA (see page 7), and that country's defence forces will not normally be directed against hostile targets by NATO. The members of the original six-nation consortium which evolved NADGE are Hughes Aircraft Company, USA; Marconi Radar Systems, UK; AEG Aktiengesellschaft, Germany; Thomson-CSF, France; Selenia SpA, Italy and NV Hollandse Signaalapparaten, Netherlands. There are also numerous subcontractors from all the participating countries which are receiving orders in relation to their own country's contribution to the funding of the project.

NADGE was conceived as an overall plan for the improvement of existing hardware and the provision of new equipment in certain areas. Improvements to individual national air defence networks are in progress in several NATO countries and these will all be engineered to complement and enhance the overall NADGE capability. Portugal is obtaining three Hughes HADR H-3000 3D radars and Norway has also acquired three HADRs. Norsk Forsvarsteknologi (Hughes and Kongsberg) are producing 18 AN/TPQ-36 derived Low Altitude Surveillance Radars (LASR) to form a low level acquisition radar and control system (ARCS) of air defence. The computer-based ARCS is used with the HAWK missile system where it replaces three radars and multiple control centres. Germany has selected the AN/FPS-117 radar for three NATO defence sites under a \$65 million contract.

The NATO E-3 AWACS fleet is now in full operation and both the United Kingdom and France have agreed to buy these aircraft for their own early warning system and co-operation with the NATO fleet. The United Kingdom has ordered seven aircraft and France four. The first aircraft for each country has already been delivered. The Airborne Early Warning/Ground Environment Integration Segment (AEGIS) programme provides for the controlled exchange of air surveillance data between the NADGE system and the AWACS aircraft by augmenting existing ground facilities. It enables the processing of in-flight AWACS radar data for dissemination to command control installations throughout Europe from Scandinavia to Turkey. The first two AEGIS ground stations became operational in 1983, in Denmark and Germany and the complete system is now operational. In addition, automated command and control information systems have been installed in a number of countries to give NATO commanders current information on

the disposition and readiness of their forces in the field, and provide information on enemy air activities through the use of high speed computers.

A NATO requirement for a number of E/F-band 3D surveillance radars for Italy, Greece, Turkey and Portugal to upgrade the NATO southern flank has been met by the order of 10 Hughes HR-3000 systems, three each for Portugal and Turkey, and two each for Italy and Greece. In addition, two NATO competitions for D-band (23 cm) long-range surveillance radars are in progress for Greece and Italy.

To improve detection of low-flying intruders, Denmark has installed the Coastal Radar Integration System (CRIS) which links data from Danish coastal radars surveying the Kattegat and the Western Baltic. In mid-1986 THORN EMI Electronics installed this system to feed information from the coastal radar network to the Danish elements of NADGE.

The NADGE system is continuously evolving and, in addition to the ACCS programme described below, a number of other updating plans are in progress. In August 1990 it was disclosed that Thomson-CSF has signed a contract to supply 14 mobile TRS-22XX air surveillance radars for integration into Turkey's air defence network. Turkey also needs a new major communications network, known as the Turkish Air Force Integrated Communications System (TAFICS). Selenia has won contracts to improve the Italian national air defence network with an Argos-10 long-range surveillance system in Sicily, and has provided 14 RAT-31S E/F transportable 3D radars. Germany has developed a low level system to meet national requirements consisting of Siemens DR 641 radars in a TRMS mobile system. Most of these programmes are national in concept but all contribute to the overall NADGE system.

### Air Command and Control System

NADGE was originally conceived as a purely defensive system against manned aircraft. However, new threats have emerged and these, together with future threat evolution, need to be met by a completely integrated defensive and offensive system. An on-going study has been carried out within NATO for the Air Command and Control System (ACCS) to provide a NADGE update which will ultimately provide overall air control of all types of air activity within Allied Command Europe (ACE). It is intended that this should be evolutionary in nature, starting with existing facilities and types of organisation for NATO air force control, and proceeding from that point to meet future requirements in a number of stages. By the year 2000, or shortly after, NATO intends to have vastly improved the command and control system of its air forces by implementing a system that will bring together, expand, modernise and automate all relevant subsystems and components of control.

The ACCS programme is currently in the planning stage, and a NATO ACCS team was established, with the creation of ACCS commencing in 1991. The execution of ACCS will be based on a five-part master plan, and in view of the importance of the ACCS programme, both politically and economically, industry has co-operated to form two international consortia, ACCSCO (ACCS Company) and AMS (Airspace Management System). The first consists of Siemens, AEG-Telefunken, Marconi, Plessey, MBL, Selenia, Hollandse Signaalapparaten, Thomson-CSF and Hughes Aircraft Company. The second consortium comprises Boeing, Westinghouse, ESG, SEL, Thomson-CSF, ISR, Racal Radar, Logica and Italtel. The two consortia



differ to some extent in their approach to the ACCS programme in that AMS believes in the early introduction of new technology and operational doctrines, while ASSCO believes in using the existing system as a foundation on which new equipments and technologies can be built.

To date, four contracts worth a total of \$10 million have been awarded to the two consortia for the ACCS Multi-sensor Integration Study and the Communication and Automated Data Processing Design Options Study. In addition, AMS has won a contract for the ACCS DataBase Implementation and Automated Data Processing Support Tools Study.

However, the ACCS master plan has recently run into difficulties particularly in relation to the overall system cost which has been estimated at \$25 billion. In addition, the disbandment of the original ACCS team, lack of a standard NATO Identification System (NIS), which has been cancelled, and the integration of data fusion are all posing considerable hurdles.

ACCS was conceived to meet requirements of the NATO central front and with the diminishing threat appears to be a redundant project, or at least one that could be scaled down considerably. NATO is currently re-examining the whole question of ACCS with, perhaps, more emphasis on the southern and south-eastern flank where the threat is seen to be increasing.

*An air defence commander in a German NADGE (NATO Air Defence Ground Environment) centre provides instructions to the E-3A AWACS early warning aircraft through the digital manual input station (MIS) under new capabilities provided by AEGIS (Airborne Early Warning 'Ground Environment Integration Segment')*

## NETHERLANDS

As with most other West European nations the Dutch national air defence system forms an integral part of the NATO NADGE network (see separate entry). With the delay in the ACCS programme the Netherlands has combined with Germany and Belgium to consider the implementation of a Central Region Initial ACCS Programme (CRIAP) to upgrade their air defence ground environment networks.

One interesting system, produced by Hollandse Signaalapparaten, is an integrated coastal surveillance, command and control network, known as Watchdog. Its primary objective is collecting, processing and presenting clear information in order to evaluate continuously the coastal situation, and safeguard against low level air attack maritime intruders. In its most extended configuration, the primary sources of information are coastal radar stations, direction finding stations and thermal imaging posts. Target data and other tactical information are fed into the system computer and continuously updated, correlated, stored and distributed to other users, as well as being presented on operator displays together with computer-generated geographical maps of the area concerned.

The Royal Netherlands Air Force forms part of NATO's Second Tactical Air Force. The fighter/bomber element consists of F-16 aircraft and NF-5s. More F-16s are being delivered and by 1992 the total force should consist of over 200 of these aircraft. SAM forces comprise nine squadrons with I-HAWKS and four Patriot squadrons.

Late in 1991 it was stated that the Royal Netherlands Air Force plans to relocate its eight German based SAM squadrons to the Netherlands and at the same time Dutch Patriot squadrons and Improved HAWK units are to be merged into four composite squadrons. Additional details are given in the inventory section at the end of this book.



*Operator's console at the harbour operations centre, Ymuiden*

## NIGERIA

In the mid-1980s Nigeria continued a programme of refurbishment and upgrading of its national air defence infrastructure, including the airspace control service. A Selenia RAT-31S was procured and has been in operation at Lagos for civil/military purposes, including control of nearby AA units consisting of guns and Roland SAM units. Elsewhere in Nigeria, ATC radars that had been shut down for many months were reactivated.

Since 1985, however, with the considerable decline in oil revenues the

Nigerian economy has been in a perilous state and savage cuts had to be made in defence expenditure during 1986 and 1987. In 1988 the government announced a considerable rise in the defence budget to offset the two previous years. It seems doubtful, however, if any of the budget will be used for procurement of new air defence equipment. Main air defences consist of Jaguar, Alpha Jet and MiG-21 'Fishbed' fighters with 16 mobile Roland SAM systems and Blowpipe manportable SAMs.



## NORWAY

As a member of NATO, Norwegian air defence is integrated into the NADGE system. Included in this system are three Hughes Air Defence 3D radars which were built in the 1983-1988 period, two in southern Norway and one in the north. These radars, known as SINDRE, are used in shelters positioned on top of mountains, with the antennas mounted on elevators so that they can be retracted into the environmentally controlled hardened silos for routine maintenance, or in case of attack. Two more silo-based radars are planned for installation on mountain tops at Njunis and Innhesten in northern Norway. Due to the rough terrain and the altitude, construction is expected to take three and a half years for the former and five years for the latter. There is also extensive use of passive sensors, particularly along the 196 km border with the Soviet Union.

Modernisation of the Norwegian control and warning system is being co-ordinated with recommendations of the ACCS plan (however, see the NATO entry). In addition, Norway and Denmark are acquiring an automated Command and Control Information System (CCIS) for NATO's northern Europe command. This is being implemented in two stages, and initial results have promised to greatly enhance command and control capabilities.

For defence against low level attack, Norway has introduced the NOAH (Norwegian Adapted HAWK) programme to lengthen the operational life of the HAWK weapon system beyond the year 2000. This includes a new generation of mobile air defence radars, the AN/TPQ-36A, developed by Hughes. The radar is deployed with a fire control distribution centre developed by Norway's Kongsberg Vaapenfabrik as part of a new adapted HAWK missile system called the Acquisition Radar and Control Centre (ARCS). A single ARCS is able to replace the three radars and two control units needed to operate the three launchers in the Improved HAWK battery configuration. NOAH has the communications capability to net information from two or more sensors, thus providing an integrated tactical air defence picture giving early warning and battle control. A joint venture company,

Hughes Kongsberg Vaapenfabrik (HKV) was formed and the programme has now been completed successfully with the delivery of 24 ARCS equipments.

In December 1988 a contract was awarded to NFT and Hughes for system design and test of a new medium-range surface-to-air defence system, known as the Norwegian Advanced Surface-to-Air Missile System (NASAMS). This is based on NOAH and a land-launched version of the Advanced Medium-Range Air-to-Air Missile (AMRAAM). Development has begun on a new launcher, equipped with six AMRAAMs, with three launchers constituting a fire unit. Completion of the production of three batteries, each comprising three fire units, is scheduled for June 1993. The final phase, in the second half of the 1990s, is an option for 25 batteries.

The Norwegian Army has ordered the NALLADS (Norwegian Army Low Level Air Defence System) radar unit, mounted on a Hägglund Bv 206 vehicle. The system is designated NO-MPY-1 and controls the army's Bofors RBS 70 surface-to-air missile system.

The Royal Norwegian Air Force assigns much of its strength to NATO. The strike/interceptor force consists of F-16A/Bs and F-5A/Bs, although 50 per cent of the F-5A/B force is being upgraded for an ESM role. The RBS 70 SAM is used for airbase defence.

Late in 1991 the Norwegian MoD announced its budget for 1992 which in real terms represents zero growth.

It was stated that air defence measures included continued Norwegian contribution to the operational costs and maintenance of the NATO owned E-3A AWACS stationed in Norway, launch of production of NASAMS in 1992 with contract for first two batteries. The air force will also receive funding for modernisation of the short-range L/70 40 mm anti-aircraft gun system to FCS2000 standard. Deliveries of RBS 70 will continue through to 1992. In addition funding will be provided for the acquisition of new SINDRE radars for northern Norway.

## OMAN

The air defences of the Sultanate of Oman have undergone two major modernisation and improvement programmes, one in the early 1970s and the second in 1985. The first of these, carried out by British Aerospace, provided a highly mobile and accurate integrated air defence system capable of protecting civil or military installations from air or ground attack and able to intercept intruders within Oman or its surrounding waters. The hardware selected for these tasks consisted of 28 Rapier fire units, equipped with Blindfire radars, and Jaguar tactical aircraft. The current combat aircraft strength amounts to 22 Jaguars and 13 BAe Strikemasters, plus 17 Hunters. The radar and communications networks needed to provide adequate early warning, and command and control links to the defence forces, were supplied and installed largely by Marconi.

In mid-1985 it was announced that Marconi had received a £38 million contract to extend and update the air defence network. The major items of new equipment were two Martello S713 long-range 3D radars with their associated display and handling systems. These have now been delivered and are fully operational. Part of the contract also included updating and expanding existing Sector Operations Centres (SOC), and Control and Reporting Centres (CRC), as well as provision of a new CRC.

The communications system has two main centres connected by terminal and repeater stations. These link the air defence operations centre with the two SOC, each of which has its own surveillance radar station. Defence centres in the vicinity of Muscat in the north and along the border with

Yemen in the south are linked by a tropospheric scatter system. This network is used to convey processed data and communications from radar sites and SOC to the main operations centre.

Eight Tornado air defence fighters were ordered to update the fighter force but delivery has had to be cancelled because of economic reasons. Sixteen BAe Hawk 100/200 aircraft have been ordered to replace the ageing Hunters.



Marconi Radar S600 series search and heightfinder radars deployed in the desert

## PAKISTAN

Pakistan is in the course of setting up a new air defence system based on a ground radar chain with stations at Karachi, Lahore, Pasni, Islamabad, Rahimyarkham and Jiwani. The radar systems are being supplied by Thomson-CSF of France but no information on the types of radar concerned have emerged, although they are probably of the TRS-2215 and/or TRS-2230 type (mobile and fixed/relocatable systems respectively). Six radars are reported to have been ordered but there are no indications as to whether any part of the system will be locally manufactured. Already in service are a number of Westinghouse AN/TPS-43 radars, as well as one old AN/FPS-100. Pakistan has also acquired a number of US-built low level air defence radars, which transmit target acquisition information to fire control radars and firing posts.

In addition, a number of German secondary surveillance 'gap filling' radars are employed. The majority of these older radars are deployed near the Indian border and it is understood that the new French systems are likely to be similarly deployed. Pakistan also has some Giraffe air defence radars. For airborne surveillance, Pakistan was interested in the Boeing E-3, but this was eventually dropped because of funding shortfalls. However, part of a 1989 military assistance programme request from Pakistan to the USA included interest in several AWACS aircraft. According to the US DoD

a study was being made into the feasibility of supplying an airborne early warning system.

Since the announcement of this new air defence system in early 1988 new governments have been elected following the death of President Zia. Whether this will have any effect on the procurement of the equipments remains to be seen.

The Pakistan Air Force consists of a mixture of American, French and Chinese aircraft. The main interceptor force consists of F-6 and F-7P aircraft and F-16A Fighting Falcons whilst the ground attack/close air support fleet comprises Mirage IIIEP, Mirage 5PA/5PA2/5PA3, Shenyang A-5 Fantans and Mirage IIIRP. A further 71 F-16s were on order from the United States, under a programme known as Peace Gate, and 60 additional F-7Ps are being purchased from China to replace the F-6 aircraft. Fifty Mirage IIIOs have been obtained second-hand from the Royal Australian Air Force. In 1991 the F-16 order was suspended by the United States because of its displeasure over Pakistan's nuclear programme. The army and air force SAM units use Crotale, HQ-2, Anza, Stinger and the RBS 70, part of the latter being locally manufactured under licence. There is also a wide variety of static and mobile anti-aircraft guns.

## PHILIPPINES

Although independent since 1946, the Philippines has relied almost entirely on the United States for its defence, and this is reflected in the inventory of the Philippine forces. The USA enjoys important base facilities in the country, notably at Subic Bay naval base and Clark air force base. A number of surveillance radars have been supplied by various manufacturers. The complete extent of the Philippines air defence radar network has never been disclosed, but it includes two Selenia ATR-3T radars supplied for ATC purposes at Manila and Mactan in 1972 which can be used in a supplementary surveillance role. In addition, four ITT-Gilfillan 320 Series 3D transportable air defence radars have also been delivered.

The US base facilities have provided a guarantee against external attack but the lease expired in September 1991. Details of the eventual agreement were not fully publicised but it is noteworthy that the Philippine Government announced a 30 per cent increase in its defence budget for 1989, which was made possible by the new military bases agreement with the US. The US had threatened to pull out altogether if the Philippine Government did not moderate its requirements, possibly rebasing on the island of Guam. It

is of interest to note that the USSR has already made a proposal to close Soviet bases in North Vietnam if the US will close its bases in the Philippines.

The Philippines Government is far from happy about the presence of the US forces and would prefer not to have foreign troops on its soil. Although the Philippine islands occupy a strategic position in the Pacific, there has been a softening of the US position over the latter part of 1990. This is partly due to the diminished Soviet threat in the area, and partly for economic reasons based on the cost of compensation to the Philippines Government and the upkeep of the bases. After some months of protracted negotiations, the military base treaty finally collapsed in September 1991 and the United States was given three years to withdraw from Subic Bay.

The Philippines Air Force is quite small, consisting of one interceptor squadron with F-5A aircraft. A relatively large number of COIN aircraft are also operated. Deliveries have commenced of 18 SIAI-Marchetti S.211 basic jet trainer/light attack aircraft, some of which will be used for training and others for ground support. The 1990 defence budget amounted to just over \$1 billion, approximately 10 per cent of the national budget.

## PORTUGAL

As a member of NATO, the Portuguese air defence system has become part of the NADGE network (see separate entry), and in 1985 a Hughes HR-3000 radar was ordered by NATO and installed in Portugal to supplement the NADGE chain in southern Europe. Since then Portugal itself has ordered a further two HR-3000 systems. The US has delivered five tracked Chaparral SAM systems and associated alerting radars. An Improved HAWK battery has also been supplied together with Blowpipe manportable SAMs from the UK.

Requests for Proposals (RFPs) on the \$160 million Portuguese Air Command and Control Systems 2 (POACCS 2) were issued in November 1989. The system will provide Portugal with an advanced command and

control system for airspace management as part of the overall NATO air defence strategy. It will also be one of the first components of the NATO ACCS architecture (see NATO entry).

The Portuguese Air Force is quite small and consists mainly of A-7P fighter-bombers and G-91R3/G-91R4s for ground attack work. Twenty ex-USAF F-16A/Bs are being delivered, with a possibility of more being ordered.

Late in 1989 Portugal took delivery of a Siemens Battery Co-ordination Post (BCP) together with 12 weapon terminals. The BCP acquires, tracks, identifies and engages targets at short-range and the Portuguese Army will use it in conjunction with Chaparrals, manportable SAMs and towed anti-aircraft guns.

## SAUDI ARABIA

The original Saudi Arabian air defence network was provided in the 1960s and was based on UK and US radars. A succession of improvements have been grafted on to this basic system over the past 20 years, either for overall system enhancement or as adjuncts or essential elements of a new weapon system. A considerable amount of defence equipment was purchased from France and included a Thomson-CSF TACCS (Thomson Air Command and Control System) for air defence purposes. In 1980 the US supplied four Westinghouse AN/TPS-43 3D radars, and in 1981 AN/TPS-43G radars were ordered, in addition to modifying the original systems to the 43G standard under the Peace Pulse programme. At the time the US deployed a number of AWACS aircraft to serve as an airborne command post based in Saudi Arabia.

To further strengthen air defences in the area, defence ministers from six Arab states in the Gulf area agreed in principle to establish an air defence system based on Saudi Arabian airborne warning and control aircraft. The states concerned are Saudi Arabia, Kuwait, United Arab Emirates, Bahrain, Qatar and Oman. The overall project is known as Peace Shield and was finalised to include five E-3 AWACS aircraft, eight Boeing KE-3A tanker aircraft, a command, control and communications complex with underground command centres, data processing and communication links, and a new ground network of 17 GE Aerospace AN/FPS-117(V)3 long-range radars, similar to the North American Warning System. Work on the programme, which was estimated to cost \$8.5 billion, commenced in 1981 and by 1988 the centralised command operations centre had been constructed and



work on building and connecting five sector command and operations centres had been completed. However the overall Peace Shield programme has run into serious technical difficulties. When the contracting authority, the USAF Systems Command, Electronic Systems Division awarded the contract to Boeing the system was due to be operational by 1988. By January 1991 this had slipped to 1995. Consequently the USAF cancelled the part of the Boeing contract related to software and hired three other companies to study how they would complete the programme. After a competitive evaluation, the USAF awarded a contract worth nearly \$900 million to Hughes Aircraft Company. The new system will integrate command and control system data processing, displays and communications at major facilities and smaller sites throughout Saudi Arabia. It will integrate a large number of existing radar and communications equipment with Hughes workstations, large screen displays, modem data processing and software. The first E-3 aircraft was delivered in June 1986 and all 13 aircraft are now in operation. The Royal Saudi Arabian Air Force has received 47 F-15C Eagles from the USA and is procuring 24 Tornado ADV fighters from the UK, and more F-15s from the United States. The main SAM force consists of Improved HAWK, Crotale and Shahine systems.

In March 1989 Saudi Arabia signed the first phase of a contract for a tactical radar system known as Falcon Eye, which is to form a part of the integrated air defence network. This programme is under the Al Yamamah defence procurement agreement between the UK and Saudi Arabia and involves the supply of Westinghouse AN/TPS-70 radars with all related computers, software, communications and systems integration managed by Ferranti. The Falcon Eye system will integrate data from the AWACS fleet and the ground radars, and is compatible with the existing Peace Shield and Peace Pulse programmes. The new radars will be downlinked to the 14 Skyguard/Gun King equipped air defence batteries which provide protection for military bases and other vital installations. Delivery of the first phase was completed in the Spring of 1991 and commissioning work is now in progress. This phase is intended to provide interim regional/sector air defence command facilities before the more comprehensive network in the late 1990s. As a result of the Gulf War six Patriot fire units are being delivered from US Army stocks.

## SINGAPORE

During 1980 an integrated civil/military surveillance system based on the LAR II D-band radar with associated data handling equipment, manufactured by Hollandse Signaalapparaten of the Netherlands, was supplied. Most of the hardware is located at Changi International Airport and the data stored in this system is available to both civil and military authorities. In 1982, in a move seen in some quarters as a preliminary to the formation of a regional air defence system embracing five ASEAN states (Indonesia, Malaysia, the

Philippines, Singapore and Thailand), Singapore ordered four Grumman E-2C early warning aircraft. These aircraft are now operational with the Singapore Air Force and provide airborne surveillance over much of South-East Asia's airspace. The fighter force comprises F-5E and F-16A aircraft plus a large number of A-4 Skyhawks which are being upgraded. SAM defence comprises Rapier, Improved HAWK and RBS 70.

## SPAIN

Combat Grande is the name of the programme of automation of the Spanish air defence system by the USAF for the Spanish Government, supplied by a jointly owned Spanish-American company registered in California. Funding for the first two phases of this programme has been provided by the US, which may also approve funds for the third and fourth phases. Combat Grande will be linked into the NATO NADGE network.

The original programme was intended to automate Spain's manual air defence system by developing a combat operations centre, sector operations centres and modernising a number of long-range radar and communications sites. The programme also called for the improvement and enlargement of an existing microwave communications system. Included in the radar enhancements have been the provision of new IFF/SIF facilities, video extractors and modems. A capability for remote operation of the radar site ground/air communications was also provided.

The system employs the Hughes H5118M computer, and the Radex system developed by Hughes in an earlier defence programme provides video extraction and signal processing facilities. Although never officially confirmed the Westinghouse AN/TPS-43E radar is reported to be the centrepiece of Combat Grande.

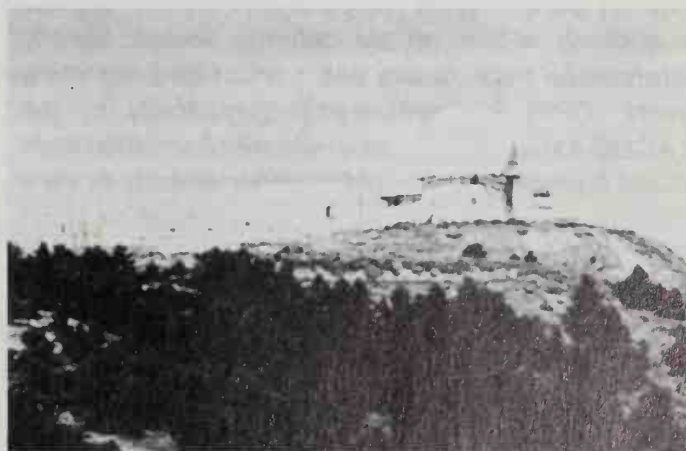
The second phase of the programme, unofficially known as Combat Grande II, has made additions to the radar facilities, and new microwave communications have been installed to improve network data exchange services. Between 1980 and 1982 Collins data transmission equipment replaced outdated hardware at 44 sites being modernised to improve transmission of data to Torrejon Air Base for use in the combat operations centre. A large search radar at Brabanza Mountain in the north-west of Spain was handed over to the Spanish Air Force by the USAF Electronic Systems Division in 1984, and was the eighth air defence site to be modified. CESELSA is developing the Lanza 3D radar system to replace some of the older 2D radars. Four Lanza systems have been ordered and will be installed during the next few years.

Prime contractor for the update is COMCO Electronics Corporation, a company owned jointly by Hughes Aircraft Company and CESELSA. Each of the parent companies has a 50 per cent holding in COMCO. Hughes built the computers and designed the communications equipment for the programme; CESELSA manufactured the communications subsystems and managed the civil engineering construction.

In 1987 the Spanish Air Force set up the Mando Aéreo de Combate (MACOM) to be responsible for the air battle, both offensive and defensive, as well as the exercise of control over national airspace. MACOM is assigned air defence radars and a certain number of fighter units, with its headquarters located in Madrid. Eight air surveillance stations scattered throughout Spanish territory are equipped with heightfinding, surveillance and IFF/SIF radars from which data is passed to the nerve centre of the network in Madrid.

Modernisation of the surveillance network is still one of the highest priorities under Combat Grande, which has now reached phases III and IV. Combat Grande III will provide the network covering the Iberian peninsula and the Balearics with radar coverage at low and very low altitudes. The radars now in service will be replaced by Lanza systems. Combat Grande IV covers a similar modernisation of the Canary Islands air defence system. All these improvements will be brought together in an ACCS-E programme which will provide a link with NADGE, the French STRIDA system, and the Spanish army and navy air defence control centres. Other improvements envisaged include enhancements of communications, and the integration of mobile tactical radars into the system. The programme is likely to last until the year 2000.

The Spanish Air Force consists of four major commands, the air defence being handled by Combat Air Command. This comprises two squadrons of Mirage IIIEE, two squadrons of Mirage F-1CE, two squadrons of RF-4Cs and two squadrons of EF-18 Hornets. There is an additional squadron of Mirage F-1EEs for the Canary Islands. More EF-18s are on order. The SAM force includes Nike Hercules and Improved HAWK systems. The Spanish Army uses mobile Roland SAMs and Skyguard/Aspide SAMs as well.



One of the seven long-range radar sites in the Combat Grande Spanish air defence system. Also known as SADA, Sistema Semi-Automático de Defensa Aérea, it was produced by a jointly owned Spanish-American company, COMCO

## SWEDEN

The Swedish automatic air surveillance and operational control system, known as STRIL, is operated by the Royal Swedish Air Force. It is based on four air defence sectors, each having a sector operations centre (SOC) which receives radar data from static and mobile control and reporting centres (CRC). Inputs to the system come mainly from high and low level air surveillance radars, but a visual backup reporting service is included to supplement radar data and to replace it if necessary. Information from all these sources is fed into a central data store, from where it is extracted for selective presentation to controllers having specific territorial assignments.

The original STRIL-60 system has been the subject of a sustained development and improvement programme throughout its operational life and work is now continuing towards a new standard, known as STRIL-90. The most recent, and as far as is known, the most extensive modernisation is currently in progress. Sixteen 3D primary radars have been installed to supplement and/or replace older types and Bofors Electronics has supplied new advanced computerised display systems with such facilities as automatic tracking. The older radars were the Thomson-CSF Palmier 3D types which were used in the original NADGE system, but these have now been replaced by the ITT/Gilfillan AN/TPS-32 (Swedish designation PS806) with the antennas installed on retractable 25 m masts operated from mountain silos. Some of these sites have chambers which can house mobile control and reporting centres, with multi-processing and display subsystems provided by Marconi.

Low level surveillance is carried out by a chain of PS15 radars, developed and built by Selenia in the late 1960s. These are being replaced or supplemented by ITT/Gilfillan systems (Swedish designation PS870). Delivery of these commenced in 1987 and the programme completion is scheduled for 1993/94.

The two main examples of the Bofors Electronics family of transportable air defence operations centres (TADOC) used in the STRIL system are the TADOC 311 and 431. The latter is the more sophisticated with regard to the operational functions and computing power. These centres can be moved to new locations easily if strategic plans are changed or if it becomes necessary to replace other centres destroyed by enemy action.

## TADOC 311

Normally, the TADOC 311 interacts with radars in the ASCC system. Data from the radars is sent automatically to the CRC without any operator intervention. The primary radar can be of the 2D or 3D type and automatic transmission ensures fast target detection within the entire ASCC system and thus a short system response time (essential in modern air defence systems). However, since systems that may have to be used in wartime must have fall-back modes of operation, the TADOC 311 can exercise a certain amount of control in addition to its normal reporting role. This permits independent operation, should the CRC or its ground-to-ground communication fail. In addition to its 'own' local radar, the TADOC 311 can make use of a remote radar (either a military gap-filler radar or a civil radar). This remote radar delivers extracted radar data via a narrowband, telephone-type channel such as a radio link.

The TADOC 311 can also serve as a centre for visual reporting posts (VRP). Their data can be filtered by the centre and transmitted to the CRC.

Main operational tasks of the TADOC 311 include:

- (a) producing target information and transmitting it to the CRC. This is normally automated for radar data (transmission of extracted radar data or plot messages). There is, however, a manual backup function that can be used if the radar or extractor function is degraded. The manual backup function can also be used to filter and transmit target information obtained from VRPs
- (b) ECCM control, which entails evaluation of the ECM situation and the taking of appropriate countermeasures to eliminate or alleviate the consequences of jamming.

Secondary operational tasks include:

- (c) autonomous airspace surveillance, which is carried out within the area covered by the connected radar station(s) in the event that ground communication to the CRC or the CRC itself is out of action
- (d) weapons control, primarily control of fighter aircraft in the situations cited above
- (e) producing target information and transmitting it to nearby SAM/AAA units. This can be performed using the manual backup function mentioned earlier.

## TADOC 431

Normally the TADOC 431 serves as a tactical operations centre such as a CRC in the ASCC system. The TADOC 431 is responsible for all tactical operations within an air defence sector. Sensor information from radars and control and reporting posts (CRP) is transferred automatically to the



*Operational console in a TADOC 311 air defence control cabin*

TADOC 431, which can also receive information from visual reporting posts (VRPs) either directly or via a CRP (in which the information is filtered to some extent). The received airspace information forms the basis for weapons control. The TADOC 431 also reports the airspace situation to a co-ordination centre (CC). This reporting is automatic so that the CC will receive an accurate and up-to-date airspace situation picture of the sector in question. However, since systems that may have to be used in wartime must have fall-back modes of operation, the TADOC 431 can take over some CC functions should the CC or its ground-to-ground communication fail.

The main operational tasks of the TADOC 431 include:

- (a) airspace surveillance; this is carried out utilising information obtained from connected sensors of different kinds and from subordinate centres. An airspace situation picture of the air defence sector is compiled and presented in the TADOC 431 itself and can be reported to a superior centre such as a CC
- (b) weapons control, which involves; evaluation of the threat situation, assignment of the appropriate weapon system (fighter, SAM or AAA), allocation of specific fighter aircraft or SAM/AAA unit and weapon controller, interception and recovery control of fighter aircraft or allocation of targets to SAM/AAA units. Weapons control is exercised throughout the air defence sector and is based upon the airspace situation picture
- (c) civil defence telling and base alerting; this is carried out by issuing warnings to threatened civil targets, such as highly populated areas, industrial areas and so on. Warnings are also issued to threatened air bases. Moreover, general airspace situation information is distributed to different 'customers'
- (d) co-ordination of military and civil air traffic control by organising military and civil air traffic activities in the air defence sector to ensure safety and facilitate identification of civil flights.

Secondary tasks include:

- (e) close air support and reconnaissance supervision; for the most part, this entails supervision of reconnaissance flights and supervision and/or direction of close air support aircraft. The objectives are to keep track of these aircraft and be ready to warn them of hostile aircraft
- (f) naval support and organisation by co-ordination of naval and air force activities in the air defence sector to minimise the risk of inadvertent firing on friendly units. This can also include the exchange of selected target information between the TADOC 431 and a naval command centre.

## STRIL-C

STRIL-C is scheduled to enter full operational service in the mid-1990s as part of STRIL-90 which will replace the STRIL-60. It is intended to be a very



flexible and highly automated system, able to operate with current and foreseeable sensors and communications. A complete upgrading of the SOCs and CRCs with new data processing and displays, and their associated software, together with new narrowband data link communications is under way. This will also phase in with the introduction of the new SAAB Gripen interceptor aircraft.

The new Swedish Gripen multi-role combat aircraft has now flown, albeit some two years later than planned. Operational testing is now going ahead and the aircraft will enter service into the Royal Swedish Air Force. Until that date, the RSAF air defence force comprises six ground attack squadrons, equipped mainly with Viggens, and 11 interceptor squadrons with Viggens and Drakens. In addition, three fighter/reconnaissance squadrons with Viggens are operational. Improved HAWK and RBS 70 SAMs form the main part of the air defence missile strength. First production Swedish Ordnance (previously Bofors) all weather RBS-90 SAM systems were delivered late in 1991.

**Status:** As was stated earlier, work is in progress to update the STRIL system with a new project entitled STRIL-90, which is scheduled to enter full operational service in the late 1990s. A development contract for STRI-C, worth about SEK2000 million, was awarded to Bofors Electronics in 1990, with delivery of equipment scheduled to commence in 1995. The system will be based on a version of the Bofors 9LV Mk 3 family of command and control systems, which has already been adopted for several naval programmes, and will run software written in the Ada language. This

new Bofors computer system, known as Base System 2000, is intended to be a very flexible, highly automated system able to operate with current and foreseeable sensors and communication systems. It entails a complete upgrading of the SOCs and CRCs with new data processing and display systems. Some of these operations centres will be mobile and able to move to certain prepared sites, fully equipped with new narrowband data links. It will also phase in with the introduction of the Swedish Gripen interceptor aircraft.

**Manufacturers:** Nobeltech Systems (previously Bofors Electronics) is prime contractor for STRI-C with a SEK 2 billion contract being signed between FMV and Nobeltech Systems in October 1990. STRI-C is a part of STRIL 90 which will replace the current STRIL 60. Nobeltech Systems is responsible for the development of STRI-C.

#### Defence Review

The Swedish Government is carrying out a defence review with the overall budget for 1991-92 unchanged from the previous year at SKr30.6 billion (US\$5.5 billion), with slightly increased spending over the following five years. Priority has been placed on air defence with a policy of quality rather than quantity. The Royal Swedish Air Force currently operates a force of Viggens and Drakens. The new JAS-39 Gripen programme is now well behind schedule and the aircraft is unlikely to enter service before the mid-1990s.

## SWITZERLAND

The Swiss air defence system, known as Florida, was designed and installed by Hughes Aircraft Company in the early 1970s. It is a fully computerised system consisting of a number of military radar stations with 3D radars and air defence centres. Information from the sensors is fed into conversion equipment in underground air defence centres, and processed in turn by a high speed general-purpose computer. This computer automatically establishes speed, heading and altitude of unidentified intruders and display consoles present a constantly updated picture of the aircraft's track, as well as information on the various weapons available, their launch ranges, velocities, armament, restrictions and 'time-to-kill'.

The radar used is a long-range 3D type with a planar array antenna, using the Hughes elevation frequency scanning technique. An IFF subsystem is incorporated. The processed raw data is fed to air defence direction centres where it is accepted by a computer which also accepts information from the missile sites, airfields and other military installations. It can also simulate air battles for training and instruction and can be used as a general-purpose data processing centre.

The Florida system became operational officially in April 1970. About 10 years later the Swiss Government studied the methods of updating the system, particularly in the sphere of providing air surveillance and ground control of interceptor aircraft in the lower airspace. Field tests and evaluations were held of competing systems, among them being the Hughes VSTAR and the Selenia MRCS-403 mobile air defence system with its 3D radar RAT-31S. In early 1982 it was announced that under a Swiss air defence programme called Taffir, a version of the Westinghouse AN/TPS-70(V) radar, known as Vigilant, had been ordered and was delivered in 1984 for evaluation. These trials were understood to be successful and it was reported that an order was placed for systems to be delivered in the late 1980s. However, no confirmation of this has been made.

The Air Corps is part of the army and consists of three brigades. The air force brigade operates a variety of aircraft including over 100 F-5Es, more than 50 Mirage IIIs and about 130 Hunters. Twenty BAe Hawks are being delivered, and in June 1991 the Swiss Government ordered 34 F/A-18s to replace the older aircraft.

## SYRIA

It is known that a major upgrade of the Syrian air defence system has been carried out with the assistance of Soviet equipment and technicians, but virtually no details have been disclosed. A command and control network, code named Swamp, is part of the upgrade. It has been reported also that a number of Big Bird early warning radars have been supplied by the USSR. In early 1990 a number of sources in the area stated that a series of major deals with Syria had been signed by the USSR and may amount to as much as \$1.4 billion. This involves a total refit of the country's air defence network.

Inevitably, the Syrian Air Force is composed almost entirely of Soviet aircraft. The strength, particularly considering the relatively small population of 11 million, is large with some 300 plus aircraft in the air defence category alone. These consist of some 17 squadrons with MiG-25 'Foxbat', MiG-21PF/PFMA/bis 'Fishbed', MiG-23MF 'Flogger' and MiG-29 'Fulcrum'. A total of 80 MiG-29 are on order with some 36 already delivered. The Air Defence Command has some 21 Brigades and 2 Independent Regiments with SA-2/3/5/6/8 and 11 SAM systems and various types of anti-aircraft guns. The Army uses SA-7/9/13 and 14 SAM systems with large numbers of static and mobile anti-aircraft guns.

## TAIWAN

The air defence system currently in operation in Taiwan was completed in 1980 and covers the entire country. Known as the Taiwan Air Defence Ground Environment (TADGE) or Tien Wuang (Skynet) it was designed by Hughes Aircraft Company. It replaced a largely manual system that had been in operation for many years.

TADGE is a fully automated C<sup>3</sup>I system which is based on 20 radar stations throughout the country with a central Combat Air Command and Control Centre (CACCC) at Kung Kuan, Tapei. Other control and reporting centres, with their radar systems, provide overall control of interceptor aircraft and SAM batteries against airborne intruders. The complete network

is interlocked with a sophisticated communications network, and all data is transmitted via microwave links to the CACCC. Two GE Aerospace AN/FPS-117 D-band air defence radars provide long-range surveillance and tactical control, and are assisted by two Hughes HADR systems operating in E/F-band, and a number of Westinghouse AN/TPS-43 radars.

In 1989, Hughes was awarded another contract to update the air defence system in three stages. This new project, known as Chang Wuan (Improved Net) will unify command and control of all air defence systems operated by the three armed services. Computers will be replaced or upgraded and new software programs will be incorporated. Also included in the overall project

are a number of GE Aerospace 592 radars (the transportable version on the AN/FPS-117) and the Hughes AN/TPQ-36A low altitude surveillance radar. In late 1989, the USA agreed to sell four moth-balled E-2B Hawkeye early warning aircraft, with an option for four more.

Taiwan is developing a new surface-to-air weapon system with technological assistance from the USA. It is believed that the system is currently under test and is intended to be a land-based SAM system, similar in concept to the US shipborne AEGIS, employing the Chang Bai (Long White) phased-array radar, with assistance from RCA. Taiwan's Sky

Bow 1 SAM, which uses a Patriot launcher and indigenous electronics, will be used with the system. Taiwan already has nearly 2000 SAMs, including HAWKs, Chaparrals and Nike Hercules, which are almost certainly operated by Westinghouse AN/TSQ-73 automated air defence centres. A number of Westinghouse AN/TPS-43 radars are also in operation.

Inevitably, the Taiwan Air Force is totally equipped with American aircraft. The interceptor/fighter strength consists of more than 220 F-5E and about 180 F-104G. A new light fighter, the Ching-Kuo, has been developed, and the first flight took place in 1989.

## THAILAND

A programme to automate and modernise the Royal Thai Air Defence System (RTADS) at an estimated cost of \$207 million, is now in progress. The work, in three phases, is largely financed by US Foreign Military Sales Credits, and the USAF Electronic Systems Division is acting as contracting agent for the Royal Thai Air Force. It involves modernisation of the RTAF's present radar network, and also the Central Air Defence Sector command, control and communications system.

The first phase started operating in October 1989 and links radars in the central plain bordering Cambodia, and also improves coverage in Thailand's northern and eastern regions. It consists of a network of radar sensors and 31 microwave stations, many located in remote jungle areas of the country. Radars have been modernised with data extractors to support centralised tracking and weapons control. At present the radar network consists of two Westinghouse AN/TPS-43s delivered in 1980 and three AN/TPS-70s installed recently. In addition, a number of Sanders Low Level Air Detection Systems (LLADS) have been delivered.

The Systems Development Group of the Unisys Corporation is prime contractor and system integrator for this first phase. The central mode of the network is the new air operations centre/sector operations centre at Don Muang Air Base, near Bangkok which is equipped with Unisys A3/A10 mainframe computers, operator displays, large-screen display, and extensive communications equipment including special TADIL-A hardware. The team of subcontractors included Contel, Eaton, Hazeltine and VIP/IBTSOI. A unique and highly successful solution was employed to check the system before it was shipped to Thailand by using satellite

transmission of data from Thailand to the USA to test the system in a 'live' environment.

The Don Muang centre is now operational and is linked to the five RTAF radar stations by 31 microwave relay stations, six of which are located in remote jungle sites accessible only by helicopter. The radars have been updated by fitting data digitisers and have been given the capability of operating with USAF E-3 and USN E-2C AEW aircraft.

Future phases of JTADS will extend the reach of the system with improved capabilities in southern Thailand, and extend the reach of the system with additional facilities in the northern sectors. Recent reports have indicated that Thailand is considering two long-range air defence radars, and three coastal radars for low level air defence along the eastern coastline. Two GE Aerospace AN/FPS-117 air defence radars have been ordered as part of the second phase.

In July 1991 Unisys Defence Systems Inc signed a \$15 million plus contract with the Royal Thai Supreme Command Headquarters for the Thai Joint Air Defence Digital Information Network (JADDIN). This extends the use of the information provided by RTADS to the Royal Thai Army and Navy in addition to the Royal Thai Air Force.

The Contraves Skyguard low level anti-aircraft defence system has been delivered, and the Thai army has taken delivery of two Selenia Spada point defence missile systems. In addition, delivery has commenced of 18 F-16 aircraft, and the F-5E/F force is being upgraded.

The Thai defence budget for 1992 is Bt68.73 billion (\$2.75 billion) which represents a 13.5 per cent increase over 1991.

## TUNISIA

Very little is known about Tunisian air defence other than the fact that Thomson-CSF is reported to have supplied four TRS-2100 Tiger radars and two TRS-2215 systems. Tunisia still maintains strong ties with France since its independence and it is most likely that other equipment, such as control centres, will have been supplied from that country. The Tunisian Air

Force is very small and operates a few F-5E and MB-326K/L in the fighter/attack role.

Army air defence relies on a variety of static and mobile anti-aircraft guns with Chaparral and RBS 70 SAM systems.

## TURKEY

As a member country of NATO, Turkish air defence is largely integrated with that organisation. The system currently in operation is outdated and is being modernised, both from a national point of view and with the funding of NATO itself. A major programme entailing the overhaul of the Turkish defence scene is underway, with the establishment of a viable indigenous defence industry as a major factor in the programme.

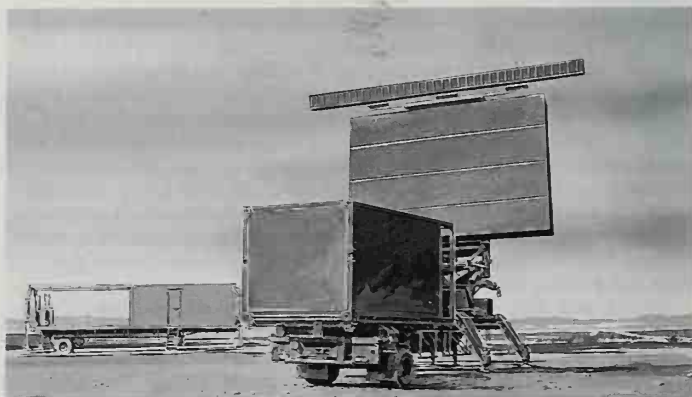
Three Hughes HR-3000 E/F-band 3D surveillance radars are being supplied with NATO funding as part of the NADGE system. Aydin Corporation of USA has signed a contract to supply a C3 system for the Turkish mobile radar complex. The contract is variously reported at between \$100 and \$200 million, and covers a six year period. It will form part of the air defence system and includes consoles, radios, other communications equipment and software. Some of the work will be carried out in Turkey by a joint venture company Aydin-Hema. Thomson-CSF is supplying 14 TRS-22XX C/F-band radars, under a \$150 million contract for this project. A joint venture company, Thomson Telken Radars has been created for manufacture of systems in Turkey.

Late in 1991 the Turkish MoD selected the GE Aerospace AN/FPS-117 solid-state radars for air defence in a NATO procurement. The initial procurement is for one radar with an option for two more with delivery to take place in 1993.

Turkey is also modernising its low level air defence and three systems are currently being evaluated, the Oerlikon ADATS, Thomson-CSF Crotale NG (*Nouvelle Génération*), and the Euromissile Roland 3. A final decision is not expected before late 1992. Surface-to-air missiles in current operation

include Rapier and Nike Hercules. In addition, 160 F-16C/D aircraft have been ordered and are being delivered with 152 being assembled in Turkey by Turkish Aerospace Industries (TAI), a joint US/Turkish company.

Current Turkish AF air defence/strike fighter assets include 54 F-5A, 24 NF-5A, 100 F-4E, 108 F-104G, 18 F-104S, 19 RF-5A and 8 RF-4E aircraft in service with a further 110 (95 F-104G and 15 NF-5A) in storage.



Artist's impression of Thomson-CSF TRS-22XX air surveillance radar



## UNION OF SOVIET SOCIALIST REPUBLICS

**Note:** With the break-up of the Soviet Union into its constituent republics, the current situation regarding its air defence assets remains obscure. If the republics agree to form a loose union for economic and defence reasons, then the air defence may well remain a unified structure. If some of the republics choose to be completely independent it is difficult to envisage what will become of the overall air defence. The details given below represent the air defence situation immediately prior to the break-up.

The signing of the START agreement in Moscow a few months ago brings a question mark over the whole air defence system of the Soviet Union. Additionally the somewhat parlous economic state of the country makes it difficult to imagine large sums of money being spent to maintain and upgrade the present system.

The Soviet Union maintains an elaborate and extensive air and space defence network consisting of a variety of organisational levels equipped with a multiplicity of sensors, systems and command and control levels which are frequently interdependent and overlap to provide redundancy.

### Early Warning

What is claimed as the world's most comprehensive early warning system separately provides for detection and alerting to both ballistic missile attack and conventional air attack by missiles and aircraft within the atmosphere. The current ballistic missile early warning system consists of a launch detection satellite network, over-the-horizon (OTH) radars, and a series of large phased-array radars on the periphery of the Soviet Union.

The launch detection satellite system can give a warning of any US ICBM launch, as well as determining the area from which it was launched. Two large radars of the OTH type are in operation facing US ICBM sites and could provide up to 30 minutes warning of attack. Two additional OTH systems have joined them to improve coverage and monitor US ship and aircraft movements in the Pacific area, and also cover the eastern border of the USSR with China. It is not known how effective these radars are but, judging from the problems that the US has had with the development and operation of its own OTH programme, perhaps too much emphasis should not be put on their capability.

The next layer of ballistic early warning facilities consists of 11 Hen House large detection and tracking radars located at six sites on the Soviet periphery, and these can confirm the warning of an attack given by the satellite and OTH networks and give an indication of its scale. The Hen House radars are also able to provide certain target tracking data in support of ABM deployments.

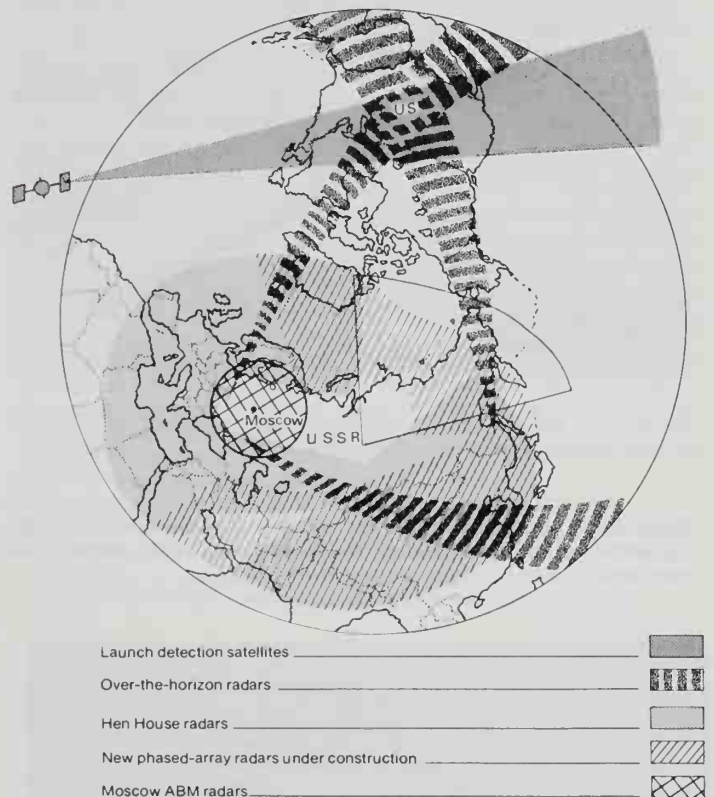
The construction of new large phased-array radars is continuing with three new systems being built on the periphery of the USSR. It is believed that there are seven under construction, which will carry out upgrading of the ballistic missile defences. It has now been agreed that the controversial radar at Krasnoyarsk, in Siberia, will be dismantled. The entire network of large phased-array radars will form almost a complete circle around the USSR, with the complete system being operational by the mid-1990s. This will provide ABM battle management beyond Moscow.

The new phased-array radars duplicate or supplement the 11 existing Hen House systems at six locations on the USSR periphery. They are believed to be able to track more attacking missiles with greater accuracy than the existing network, covering almost all approaches to the Soviet Union. This will allow the USSR to establish a national ABM network system rather than the one based on Moscow at present.

### Ballistic Missile Defence

Throughout the past 10 years or so the Soviet Union has been working to upgrade the Moscow ABM system. The original single-layer ABM system included 64 reloadable launchers above ground at four complexes for the 'Galosh' ABM-1b, six 'Try Add' guidance and engagement radars at each complex, and the Dog House and Cat House target tracking radars to the south of Moscow. This system is now being upgraded to the 100 launchers allowed by the 1972 treaty; in the interim there have been only 16 'Galosh' deployed. The system became partly operational in 1989 and is now a two-layered system consisting of: silo-based long-range modified 'Galosh' interceptors designed to engage targets outside the atmosphere; silo-based high-acceleration SH-08 'Gazelle' interceptor missiles to engage targets within the atmosphere, associated engagement and guidance radars; and the massive new Pill Box four-sided, phased-array radar at Pushkino, north of Moscow, designed to control ABM engagements. The multi-function radar provides 360° coverage against incoming missiles and was due to become operational in 1990.

Late in 1991 the US DoD stated that the older Galosh ABM was being replaced by the new Gorgon, the latter is launched from above ground and is designed for exoatmospheric intercept.



*Coverage of ballistic missile detection and tracking systems*

The SA-10 'Grumble' SAM has now been deployed at nearly 100 sites, many of which are near Moscow. A mobile version, the SA-10b, is also being deployed. Also in operational use is the SA-12a 'Gladiator' mobile SAM, while a longer range, higher altitude version, the SA-12b 'Giant', is about to enter service. This SAM is reported to be capable of intercepting aircraft at all altitudes as well as cruise missiles and tactical ballistic missiles.

Modern Soviet surface warships equipped with the SA-N-6, the naval version of the SA-10 are integrated into the strategic SAM network and extend the network farther from the Soviet Union.

The new Kuznetsov class aircraft carriers will have an air wing composed at least partly of Flankers, and will also augment the land-based strategic defence system.

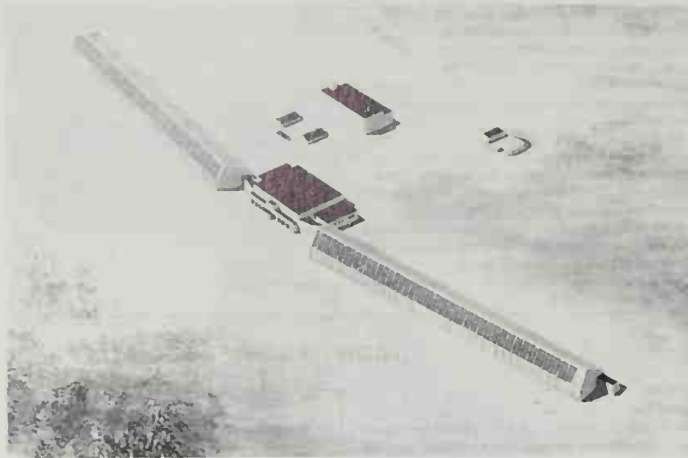
### Air Surveillance

There are an estimated 10 000 air defence radars deployed at about 1200 sites. These provide virtually complete coverage at medium to high altitudes of the Soviet airspace and in some cases for many hundreds of kilometres beyond the national borders. Limited cover against low altitude targets is concentrated in the west of the country and in certain high priority areas elsewhere, and is currently being upgraded as a result of the Cessna aircraft intruder which landed in Red Square, Moscow in 1987. A number of radar gaps are being eliminated to make undetected low level penetration more difficult. Existing air surveillance radars are being improved, with several new types in development. In addition, the data networks are being improved to enhance the exchange of data throughout the surveillance network. The programme of improvements is understood to include the partial integration of strategic and tactical defences, upgrading of early warning and surveillance facilities, and the installation of improved communications networks.

In addition to the ground surveillance systems, the Soviet Union operates a large number of airborne early warning aircraft. The original Tu-126 'Moss' AEW aircraft has now been superseded by the IL-76 'Mainstay' which uses a rotodome antenna radar similar to that employed by the US Boeing E-3.

The Soviet Air Force is the largest in the world and is divided into four main parts, known as Long Range Aviation, Air Defence Force, Frontal Aviation (Tactical Force) and Air Transport Aviation.

Each part has its own role, organisation, command structure and equipment. Approximately 2220 air defence interceptor aircraft are dedicated to strategic defence, with an additional 1700 interceptors that could be



Eleven of the large Hen House ballistic early warning radars are located at six sites around the periphery of the Soviet Union

drawn for this purpose. Most of these additional aircraft would come from the tactical air forces segment which has more than 5000 aircraft at its command.

#### PVO Strany

PVO Strany (Voiska Protivovzduшной Strany) is the national air defence command of the Soviet Union, with an underground headquarters on the outskirts of Moscow. There are four operations/systems commands:

- (a) RV-PVO (Radio tekhnicheski Voisk-PVO) radio-technical troops
- (b) ZA-PVO (Zenitnaya Artilleriya-PVO) anti-aircraft artillery
- (c) ZRV-PVO (Zenitnaya Raketnye Voiska-PVO) anti-aircraft missile troops
- (d) IA-PVO (Istrebitel'naya Aviatsiya-PVO) fighter aviation forces.

The 10 000 or so air defence radars are the responsibility of the RV-PVO, while missile systems and AA guns are in the hands of the ZA-PVO and ZRV-PVO commands. Fighter aircraft are managed by IA-PVO.

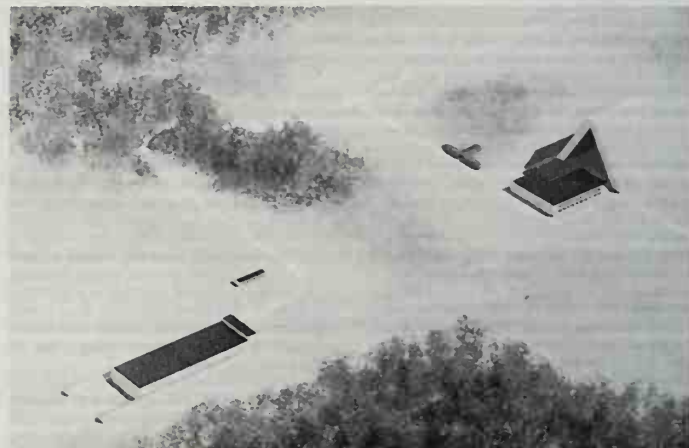
Operationally, the Soviet air defence network is divided into four levels of command responsibility: Air Defence (AD) Districts or Rayons, AD Zones, AD Sectors, and 'frontal' AD sub-units defending specific point targets. The rayons are subdivided into at least two AD zones and these are in turn divided into SAM defence sectors. Each level has a particular command function and operational mission. At rayon level these include search and entry, long-range target identification, designating air threats to lower command echelons, and authorisation of fighter intercepts or missile engagements. A total of 22 rayons cover the USSR.

The AD districts are divided into AD zones, some districts having as many as four zones, and these are under IA-PVO operational command. The command responsibilities at this level embrace target identification friend or foe (IFF), GCI radar operation and fighter intercept of hostile/unknown aircraft.

An AD sector is a specific, relatively small scale section of airspace under the control of Air Defence Launch Command Centres, and their defence is based on SAMs and their associated target tracking and guidance radars.

#### Passive Defence

The Soviet Ministry of Defence controls the nationwide civil defence programmes of the USSR. The Chief of Civil Defence is a Deputy Minister of Defence and General of the Army. Full-time civil defence staff exist at each echelon of the Soviet administrative structure. Civil defence staff also exist at significant industrial, utility and other installations. In wartime, the civil defence administrative structure, assimilated into an integrated command system, would play a significant role in maintenance of the government and the economy. This goal is supported by the protection provided for the leadership through deep, hard, urban sheltering and an extensive network of hardened relocation sites outside the cities, with redundant communications systems. The programme also provides for continuity of support for the economy in wartime through the protection of the essential workforce by sheltering at work and by the dispersal of off-shift workers to areas away from work sites.



US artist's impression of the Soviet Dog House ABM battle management radar

## UNITED ARAB EMIRATES

The United Arab Emirates plans to spend more than \$700 million in radar and communications equipment and has recently acquired three AN/TPS-70 surveillance radars. Westinghouse has also agreed to supply command and control equipment to communicate, correlate and display real-time data from these radars. An operations centre and system to integrate air defence in the area is also planned and it is believed that Hughes Aircraft Company is negotiating with the UAE. A number of weapon systems are currently on order, including Skyguard air defence radar

systems. It is not known whether any additional air defence assets were added during the period of the Gulf War, although a number of reports had suggested that this had happened.

Current air defence assets include Mirage 2000 EAD multi-role, Mirage 2000 RAD reconnaissance, Mirage 5AD attack, Mirage 5EAD multi-role and Mirage 5RAD reconnaissance aircraft, I-HAWK low to medium level SAMs and Crotale, Rapier and RBS 70 very low to low level SAM systems.

## UNITED KINGDOM

The United Kingdom Air Defence Region (UKADR) forms one of four regional commands of the NATO integrated air defence system and stretches for about 2000 km in an arc from north of the Faroe Islands to the western flanks of continental Europe. The systems for warning of attack on the UK are BMEWS (described under the USA), and the UK Air Defence Ground Environment (UKADGE), the former being concerned with ballistic missiles and the latter with aircraft. UKADGE is also coupled into the continental air defence systems by its links with six NADGE stations.

A programme of improvement, known as improved UKADGE (IUKADGE) was instituted in 1984 and the structure of the system is illustrated in the accompanying map. Centralised command of all air defence operations in

the UK region is exercised from the Air Defence Operations Centre (ADOC) which is linked to four combined sector operations centres and command and reporting centres (SOC/CRC), with, in turn, links to command and reporting centres, and reporting posts. Links are established with the French STRIDA system at Tours and Doullens, NADGE at six sites, NATO and RAF AWACS aircraft, certain naval vessels and various defence assets such as fighter bases.

At the core of the programme is the IUKADGE Command and Control System (ICCS), which is the biggest software-based system in Europe linking command and control with land-based sensors, operational sites, aircraft and warships. The ICCS has been developed by a consortium



comprising GEC-Marconi, Siemens Plessey and Hughes Aircraft Company. It should have entered service in 1987 but delays have put this back by nearly five years. It was finally accepted into service by the UK Ministry of Defence in October 1991. IUKADGE/ICCS is the linchpin of an integrated approach to UK air defence and has suffered serious problems in integration of its component parts. The UK MoD has instituted a number of interoperability and integration studies and, in addition to the original UKSL team (Hughes/Plessey/Marconi), THORN EMI and Ferranti have been given contracts to work on a study called TRIADS (Technique for Reading an Integrated Air Defence System). This study has now been completed and is being evaluated by the MoD. It would provide IUKADGE with additional bolt-on processing and a discrete communications network for Link 16 (JTIDS).

It appears unlikely that IUKADGE/ICCS will enter service before 1992 at the earliest. If a TRIADS implementation is carried out, it would be at the end of the century before the system would be fully operational in all respects.

As far as the IUKADGE ground radar systems requirement was concerned, this called for 12 transportable systems capable of being set up at pre-surveyed sites and going into operation within six hours of arrival. This has been met by three different equipments: two D-band GE AN/TPS-592s, four D-band Marconi S723 Martellos, and six E/F-band Plessey AR-320s. Of these 12 systems, the two AN/TPS-592s, two of the Martellos, and three of the AR-320s were funded by NATO. The remaining five were funded by the UK Government. The two AN/TPS-592s have been installed at the Buchan and Benbecula sites and are operational. The four Martellos have been delivered and are also operational at various sites. Delivery of the six AR-320s began in 1987 and is complete. A fifth Martello, an S713 version, has also been delivered and is probably being used as an operational spare.

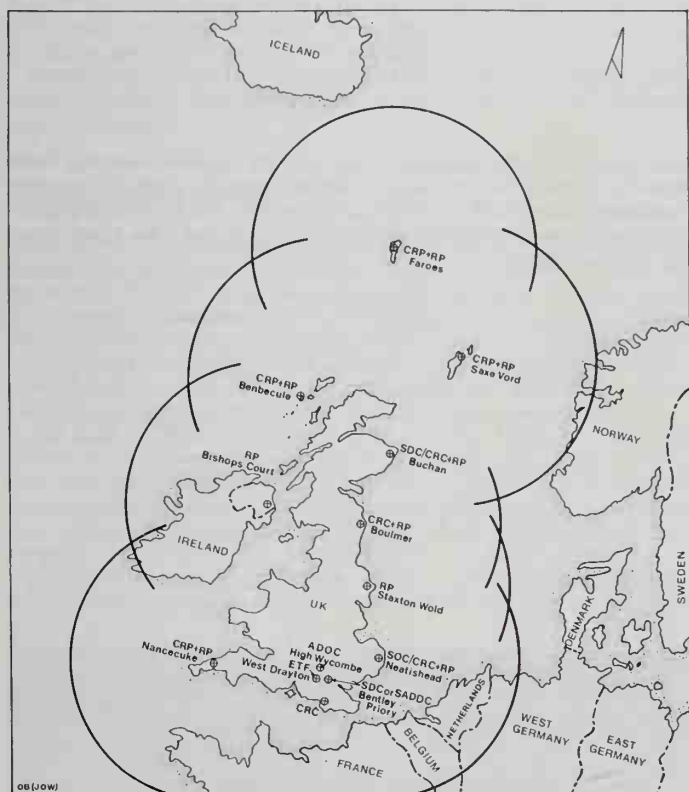
Seven Boeing E-3D Sentry AWACS aircraft were ordered by the United Kingdom and the first of these was delivered in March 1991. The remaining six aircraft have been delivered over the following 10 month period with the

last scheduled for delivery in January 1992. They have replaced the very old Shackleton aircraft which have maintained airborne early warning. Construction and installation of a network of data link stations in the UK has been completed and will enable the use of interim, and later full, JTIDS.

In August 1987 a consortium headed by ICL was awarded a £37 million contract to develop and build a new computer-based command, control and information system (CCIS), to improve the ability to control air operations strategy. The project is jointly funded by NATO and the UK MoD. It will link UKAIR HQ and a standby HQ to major RAF and USAF sites in the UK with facilities to enable UKAIR CCIS to interoperate with other UK and NATO systems, including the Central Region CCIS, UK Maritime CCIS and IUKADGE.

As with any air defence system updating UKADGE is a continuing affair and even when the complete IUKADGE system is operational there will be additional upgrading to cope with new technologies and/or threats. The complete system, including the radars, communications networks, full JTIDS and so on, will probably become fully operational in the late 1990s. The full cost of upgrading the UK's air defences was originally estimated at £7 billion (\$11.2 billion), with the cost of IUKADGE itself £1 billion. With the delays and additional requirements to the latter, these figures are likely to be considerably greater. However, the end of the Cold War will undoubtedly mean a scaling down of these requirements. The UK MoD has already announced major cuts in the armed forces and it seems unlikely that the air defence system will escape being pruned.

As a member nation of NATO, the United Kingdom contributes a large part of the Royal Air Force to that organisation. The major aircraft types in current service for interceptor work are the Tornado F-2/F-3, Phantom FGR-2 and, in times of crises, 72 Sidewinder-capable Hawk TMk1A trainers. Surface-to-air missile systems include Rapier with Blindfire radar.



Map of the major IUKADGE sites in the British Isles (Jane's Defence Weekly)



RAF personnel check out computer displays for IUKADGE, undergoing final test at Hughes Aircraft Company, Fullerton, California. Displays shown include Marconi text monitors (left), a Plessey air status display (centre), and a rear-projected HDP-4000 large screen display provided by Hughes. The improved system is produced by UKADGE Systems Ltd

## UNITED STATES OF AMERICA

The land-based air defence network of North America consists of a number of interlocking systems to protect both the United States and Canada against ballistic missile and aircraft attack. Together, they constitute the most sophisticated air defence system in the world, with its centre in the North American Air Defense Command (NORAD) Combat Operations Center within the Cheyenne Mountain complex. The main systems are BMEWS, the North Warning System, Joint Surveillance System, SLBM Detection System, Spacetrack, Navspur and the OTH radar system. Research and development for future systems is being conducted under a programme known as the Air Defense Initiative. Details of the various systems are given below.

The interceptor force comprises five squadrons of regular Air Force F-15A/C (two in the USA, two in Alaska and one in Iceland) and 12 squadrons of Air National Guard aircraft (seven with F-4C/D, four with F-16A and one, in Hawaii, with F-15A). These would be augmented in times of crises by additional units on call from the Navy, Marine Corps and Air Force.

### Ballistic Missile Early Warning System (BMEWS)

The BMEWS system consists of a small chain of very large radars for the detection of a ballistic missile attack on North America from the general direction of the USSR. There are three operational sites: at Thule, Greenland; at Clear, Alaska and at Fylingdales, UK. Information on all BMEWS targets is transferred by a communication network to the NORAD UK Combat Operations Center.

Three types of radar were used in the original system. At Thule there were four AN/FPS-50 detection radars and one AN/FPS-49 tracking radar, at Fylingdales there are three AN/FPS-49 systems, and at Clear there are three AN/FPS-50 and one AN/FPS-92 (an improved version of the AN/FPS-49). Upgrading of the system is in progress and includes replacement of the older AN/FPS-49 radars by a version of the Raytheon AN/FPS-115 Pave Paws.

The BMEWS sites have been in operation since 1962 and have proved very reliable. In conjunction with early warning satellites, the BMEWS radars comprise the principal means of warning of an attack. Additional warning of SLBM attack is provided by the SLBM Detection System, which also uses the AN/FPS-115 radars and is described later.

The upgrade programme for BMEWS includes the incorporation of new computers, new software, increased bandwidth and larger raid tracking capability. New communications facilities for links with NORAD are being installed. The programme also includes the replacement of the missile impact predictor sets (MIPS) at all three sites by replacing the original on-site IBM 7090 computers with redundant CDC 170-876 processors. ITT was awarded a contract by the USAF Space Command in late 1987 to operate and maintain the BMEWS system.

The system at Thule has been upgraded with a version of the AN/FPS-115 and became operational in 1986. A \$166 million contract for the Fylingdales update, funded jointly by the USA and UK, was given to Raytheon in June 1988 and work has commenced. Apart from updating the computers, software and communications, the main work at Fylingdales is on the radar sensor, where the three AN/FPS-49 systems are being replaced by a version of the AN/FPS-115. This particular version has three solid-state phased-array antenna faces as opposed to the two faces of Thule and the SLBM Pave Paws systems. The third BMEWS site at Clear was scheduled to be upgraded in the 1990s.

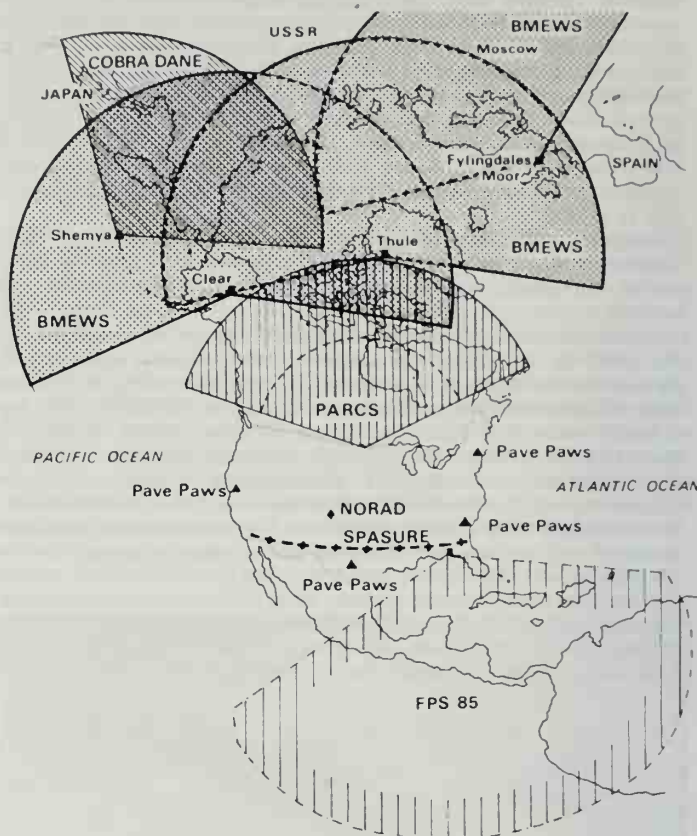
The new systems will be more accurate, have a larger track capacity and provide better prediction facilities. The radars, and the associated processing equipment, will also provide far more accurate detection and analysis of the larger number of smaller warheads in a multiple independently targetable re-entry vehicle (MIRV) attack. In addition to its ICBM related functions, the Fylingdales site will improve warning of missile attacks on NATO territory, and of SLBM attacks against North America, while enhancing surveillance of objects in space.

### North Warning System

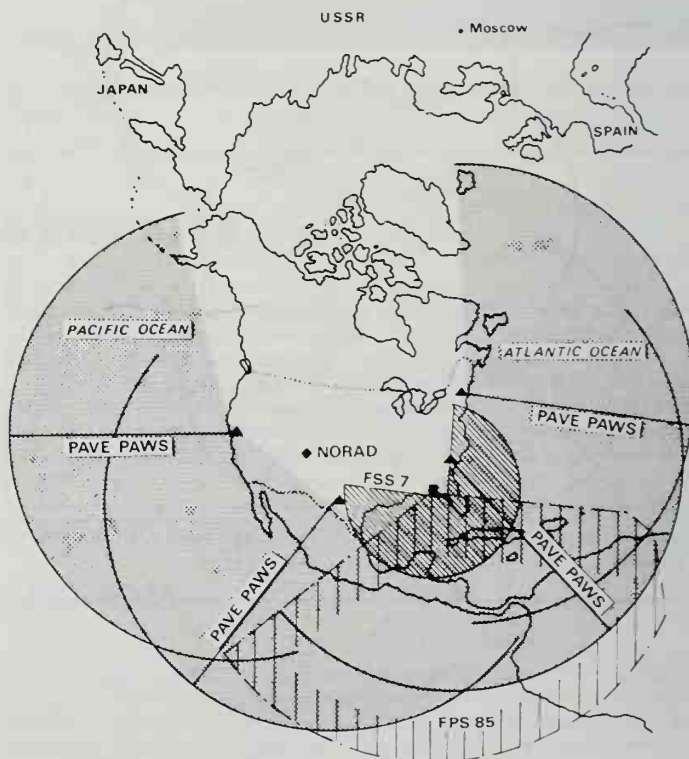
The North Warning System, previously known as the DEW (Distant Early Warning) line is one of the earlier parts of the complex of radar systems designed to warn of hostile aircraft or missile attacks on North America. It is an array of radars stretching across the northern areas of North America from Alaska, via Canada, to Greenland. The project was originally implemented as programme 413L.

The main radars of the system have been the AN/FPS-19 and the AN/FPS-30. The number in the original DEW line was 60 but this was reduced to 35 (31 in Canada and Alaska, and 4 in Greenland). This figure is being maintained while an extensive updating programme is carried out.

The updated North Warning System will consist of 13 GE AN/FPS-117 long-range radars (11 in Canada and 2 in Alaska) and 39 short-range,



Main elements of the American ICBM warning facilities protecting North America, showing the coverage of BMEWS stations, PARCS (Perimeter Acquisition Radar Attack Characterisation System), and the FPS-85 phased-array radar and SPASUR network in the south. All four Pave Paws radars are now operational



Only one AN/FSS-7 SLBM detection radar needed to be retained after the Pave Paws phased-arrays on the East and West Coasts of the USA entered service. Previously there were three FSS-7s on each coast. Although all four Pave Paws radars are now operational, the last FSS-7 and the FPS-85 will be retained for the moment



unattended Unisys AN/FPS-124 gap-filler radars. Of the 13 AN/FPS-117 radars, 10 use old DEW line sites and three are on new sites in Canada (two in Labrador and one on Baffin Island). The AN/FPS-124 systems are intended to provide short-range coverage against low-flying aircraft and cruise missiles. Computer systems, software and communications upgrades in support of the new network are also part of the improvement programme.

Unisys is responsible for the overall system engineering, the development of the short-range radars and the communications architecture. The updating programme is proceeding under a joint cost and responsibility arrangement between the United States and Canada as part of the 1985 North America Defense Modernization accord between the two countries (see entry under Canada).

As of October 1991 all the AN/FPS-117 radars were operational. The second phase, the installation of the 39 short-range radars, was well under way.

### SLBM Detection System

This system, which became operational in 1971, is designed to detect missiles launched by submarines operating either in the Atlantic or Pacific Oceans. It originally consisted of seven radars, with three located on each coast and one in Texas. The main radar used was the AN/FSS-7, but in 1972 it was decided to supplement these radars with about 20 per cent of the surveillance capability of the AN/FPS-85 radar which is otherwise assigned to the Spacetrack programme, and which can provide coverage over Central America and the Caribbean.

The system has now been completely upgraded by the use of the AN/FPS-115 Pave Paws which have been installed at Otis AFB in Massachusetts, Beale AFB California, Robins AFB Georgia and Eldorado AFB California. All four sites are operational, and these four, together with the PARCS radar in North Dakota, complete a planned five-site phased-array radar SLBM warning complex. Raytheon was awarded a contract in August 1988 to provide upgrades to the first two Pave Paws systems, those in Massachusetts and California, giving them the same enhanced data processing capabilities as the two later systems.

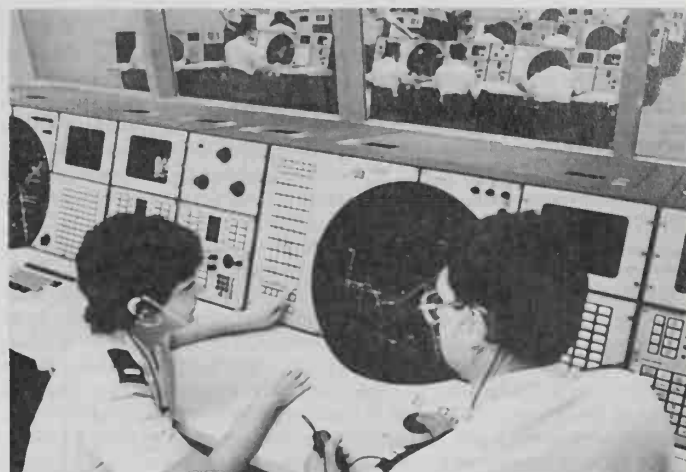
In addition to the Pave Paws programme, the USAF is developing a long-range surveillance radar programme in the Caribbean area (see entry under Caribbean).

### Joint Surveillance System

Under USAF programme 968H the Joint Surveillance System (JSS) was developed as a successor to the SAGE/BUIC system which had been the mainstay of the North American defence surveillance for some 25 years. The expression 'Joint' stems from Canadian participation and also by virtue of the fact that in the USA there is joint provision of sensors and data on the parts of the civil and military air authorities (FAA and USAF). Some hardware from SAGE/BUIC is incorporated in JSS but the latter essentially replaces the former system in performing the peacetime air sovereignty mission.

JSS centres (ROCCs) are located at Griffiss, March, McChord and Tyndall AFBs, and they receive data from 46 radar sites. Fourteen more sites feed data to another ROCC in Alaska at Elmendorf AFB, and two radar sites supply data to another ROCC in Hawaii. Some 24 air surveillance radar networks in Canada feed data to two ROCCs located at North Bay, Ontario.

The function of the ROCCs is to accept data from multiple sensors, automatically process this data, and display it for detection, tracking, and



*Console operators in the JSS Region Operations Control Centres receive information from up to 20 military and civilian radars*

identification of air targets, and the assignment and direction of interceptor aircraft to ensure peacetime sovereignty. In time of war or emergency, JSS ROCCs serve as a means of transferring the command and control functions to E-3 AWACs aircraft, and would continue as a backup to AWACS. In peacetime, six of these aircraft are assigned to co-operate with JSS.

The North American Air Defense Command (NORAD) Combat Operations Centre (COC) to which ROCC information is passed has been undergoing modification under PE 12311F, which provides for command, control and communications support to HQ NORAD. Within this PE is the NORAD Cheyenne Mountain Complex Improvement Programme (427M), and acquisition programmes to update the data processing, display and communications elements of the NORAD COC and the Space Defense Center part of the Aerospace Defense Command (ADCOM) Spacetrack system.

The overall programme for update of NORAD is known as Granite Sentry and is being implemented in five phases. Phase 1 is now complete and comprised the modernisation of the computers and display terminals in the Air Defence Operations Centre. Phase 2 includes improvement of the missile warning displays for the Cheyenne Mountain Command Post. Phase 3 provides for the updating of the space warning displays, whilst Phase 4 improves the communications processing and Command Centre data processing and display systems. The final Phase, number 5, upgrades the battle staff support centre and weather support unit. Completion of the entire programme is scheduled for late 1993.

### Over-the-horizon Radar Systems

The continental over-the-horizon backscatter radar (CONUS OTH-B) system has been developed under US Programme 414L by GE, under the auspices of the USAF Electronic Systems Division. The system is designed primarily as a defence against hostile aircraft and low-flying cruise missiles and will increase the warning of attack by air-breathing threats by extending US surveillance coverage from the American east and west coasts. It will provide all-altitude capability. A system with certain similarities, being developed by Raytheon for the US Navy, is known as ROTH (Relocatable Over-the-horizon Radar). One Raytheon OTH system is currently being constructed on Amchitka Island in the Aleutians.

The eastern segment of the CONUS OTH-B, which covers the whole of the North Atlantic approach areas over a 180° arc, has achieved limited operational status, and operational trials are being carried out currently. The complete system is due to be handed over to Tactical Air Command in 1991 as an operational system. The western section, which will cover the Pacific area in three 60° segments, is nearly complete and due to be handed over to the USAF at the end of 1990 for operational test and evaluation phases. A third four-segment section to cover the southern approaches was in the planning stage. A fourth section, based in Alaska, was in the early pre-planning stage and was designed to cover the northern Pacific along the Aleutian island chain. In addition, the USAF planned to have more systems on various islands in the Pacific in due course. A detailed description of the design and operational status of both CONUS OTH-B and ROTH is given in the *Jane's Radar and Electronic Warfare Systems* yearbook.

In March 1991 the US Government decided to cancel the CONUS OTH-B system after a review of its costs and functions. However, within a month the decision was reversed and the East and West systems will operate on a part-time basis. The central, Alaskan and Pacific CONUS OTH-B systems have been cancelled.



*North American air surveillance systems, showing OTH-B sectors for east, west and southern cover and improved DEW Line to north*

### Spacetrack

Spacetrack is the USAF worldwide system for the detection, tracking and identification of all objects in space. It consists of radar, optical and radiometric sensors located around the globe and its control centre maintains a catalogue of all objects. Information from Spacetrack is fed to the Space Defense Operations Centre (SPADOC), located at NORAD Cheyenne Mountain complex, and is part of the centrally managed Space Defense programme involving four functional areas: anti-satellite, space surveillance, space systems survivability, and command and control.

Main sensors of the systems are the AN/FPS-85 radar at Elgin AFB, the Cobra Dane radar at Shemya AFB, and the passive AN/FSR-2 optical and radiometric sensors. The AN/FPS-85 is an electronically steerable radar operating in the UHF band and giving three-dimensional information on all satellites and similar objects passing over it. The complete network of Spacetrack radar sites, in addition to the AN/FPS-85 and Cobra Dane, includes the BMEWS sites at Thule, Clear and Fylingdales (see BMEWS entry above). Other radar sites in the system are positioned at Pirinlik, Turkey and Kaena Point, Hawaii. The Pave Paws radar at Eldorado AFB, Texas also feeds information into the Spacetrack network.

The current Spacetrack optical system is a four-site Baker-Nunn camera system at San Vito, Italy; Sand Island in the Pacific; Mount John, New Zealand and Edwards AFB, California. It is capable of tracking and identifying satellites out to synchronous orbit altitudes of more than 35 000 km. Improvements continue to be made to Spacetrack sensors. The long term intention is to convert Spacetrack into a near real-time space-based system with less dependence on sites overseas.

### Navspur

Navspur is the US Navy Contribution to the overall NORAD space detection and tracking system. It detects and tracks satellites which pass through a 'detection fence' consisting of a fan-shaped radar beam extending in an east/west direction from San Diego, California to Fort Stewart, Georgia. A central transmitter is located at Lake Kickapoo, Texas. There are a total of nine stations - six receiving and three transmitting. The beam cannot be steered and detections are made when objects pass through a stationary beam. There is a single Baker-Nunn camera at Cold Lake in Canada. The Navspur headquarters and computation centre is at Dahlgren, Virginia and the nine field stations extend across the southern part of the USA along a great circle inclined at about 33° to the equator. The largest transmitter is at Lake Kickapoo and the two smaller ones at Gila River, Arizona and Lake Jordon, Atlanta. The six receiving stations are situated at: San Diego; Elephant Butte, New Mexico; Red River, Arkansas; Silver Lake, Missouri; Hawkinsville, Georgia and Fort Stewart. Other sensors feeding into the system are the three BMEWS radar stations, the USAF eastern test range radar on Ascension Island, the Space and Missile Test and Evaluation Center at Vandenberg and the Malvern radar in the UK.

### GEODSS

A major segment of the Spacetrack augmentation programme is the GEODSS (Ground Electro-Optical Deep Space Surveillance) system. An

experimental prototype was developed by Lincoln Laboratory at White Sands Missile Range, New Mexico by August 1975 and has subsequently become part of the overall GEODSS system. It consists of: two telescopes, a 31 in surveillance and a 14 in tracker, operating in tandem; associated electro-optics; a computer system with ancillary electronics; and communications equipment. The project has five sites: White Sands, Choe San Jong in South Korea, Maui in Hawaii, Diego Garcia and one in Portugal. The first four sites have now been deployed and are operational, and the Portuguese site was completed in 1989. The Maui site is a separate project in its own right and is developing techniques for rapid and accurate calibration of Spacetrack radars using US Navy transit satellites. Rockwell received a \$60 million contract in mid-1990 to develop and maintain the Maui site.

The computer provides for on-line analysis and initial presentation and it includes an automatic alarm on detecting unknown space objects. The telescope can detect objects in space which are 10 000 times below the threshold of the human eye. A form of MTI is used to control the movement of the telescopes, this being arranged to correspond with either the motion of the target or the star field.

### SPADOC

SPADOC has evolved in phases from a totally manual system in 1979 to the current semi-automatic capability. A phase IV upgrading programme is being carried out by Ford Aerospace under a USAF contract and is being accomplished in three blocks. Block A provides the basic architecture and executive software, Block B increases the NORAD Space Surveillance Center capability, and Block C incorporates a number of improvements such as semi-automated space warning, countermeasure management, evasive manoeuvre detection and strike assessment. It is intended that the complete SPADOC system will reach full operating capability by 1992.

### Air Defense Initiative

The Air Defense Initiative project is in the exploratory development stage and is intended to develop ground, airborne and space-based system concepts, and the necessary technology, for USAF future surveillance missions. Major development technology includes new surveillance radars, countering of low radar signature threats, cruise missile surveillance, and ECCM techniques against anti-radar missiles.

Little unclassified information on this project has been released by the USAF but it is understood that a number of design technologies have been completed, including a lightweight phased-array space-based radar antenna using solid-state transmitter modules, a conformal array radar for an advanced airborne surveillance radar, a lightweight surveillance radar decoy and a number of associated hardware systems.

Although there are a large number of both contractual and USAF in-house efforts involved in this programme, the project is still in the very early design and development stage. Time scales are unknown but the project appears to be aimed at the mid- to late-1990s.

## VENEZUELA

Although no specific details of dedicated air defence networks have been disclosed, it is known that a Selenia ATCR-2 long-range air traffic control radar at Maracaibo in the west, and an ATCR-3 radar in the east are used to feed information into a combined military/civil centre. In addition several Westinghouse radars, mainly the AN/TPS-43 and AN/TPS-63 types, have been installed over the past few years and fed into the network. The combined command and control centre was supplied by ITT Gilfillan and provides data processing, and both ATC and fighter control capabilities.

The Venezuelan forces include a variety of weapons specifically intended for anti-aircraft applications, including six Roland twin-launcher SAM systems and Bofors RBS 70 equipment. Nine Guardian systems, composed of the Signaal Flycatcher fire control radar and two Breda 40L70 twin 40 mm field mountings, are in service. Ten Flycatchers were acquired during the 1980s,

with 36 field mountings, and it is believed that Venezuela would like to buy another six.

Venezuela is considering upgrading its air defence infrastructure and proposes a C<sup>3</sup>I link between a new air defence/airspace management system and the point defence units. An extra command and control/low altitude surveillance radar layer, between the combined centre and the regional and local levels, is being considered to allow overall data exchange. Presentations have been made by a number of defence companies but no decision has been made.

The Venezuelan Air Force is relatively small, and consists primarily of six fighter squadrons, two with F-16As and F-16Bs, two with CF-5As and CF-5Ds, and two with Mirage IIIEVs and 5-Vs. Most of the latter are being retrofitted to Mirage 50 standard, and seven new build Mirage 50s have been ordered.



## YUGOSLAVIA

**Note:** At the time of writing Yugoslavia is embroiled in what is virtually a civil war between Serbia, Croatia and other republics constituting Yugoslavia. Whether the country breaks up into its ethnic national blocs remains to be seen.

Yugoslavia has relied in the past on Soviet and Warsaw Pact sources for much of its military equipment. It does, however, manifest a stoutly independent line in certain areas of its defence equipment. Although there is a preponderance of Warsaw Pact systems such as SA-2, SA-3, SA-6,

SA-7, SA-8, SA-9 and SA-11 SAMs, some elements of Western hardware appear in its inventory. Examples of this include six Westinghouse AN/TPS-70 3D radar systems which were acquired in the early 1980s, and the local manufacture of SA-341 'Gazelle' helicopters. The Yugoslavian Air Force is composed mainly of Soviet types, such as the MiG-21 with about 120 MiG-21bis 'Fishbed-L' and MiG-21bis-K 'Fishbed-N' and 42 MiG-29 'Fulcrum-A' in air defence service, but a locally produced light attack aircraft, the Galeb/Jastreb and strike aircraft, the Orao, have been produced in quantity.

# Manportable Surface-to-Air Missile Systems

## BRAZIL

### Orbita MSA-3.1 Low Altitude Surface-to-air High Velocity Missile System

#### Development/Description

The Brazilian companies of EMBRAER and ENGESA have joined together to form the company of ORBITA SISTEMAS AEROSPACIAS SA, which has a Military Division assigned to the development and production of missile systems for the world market.

One of the projects is a shoulder-launched surface-to-air high velocity missile, the MSA-3.1, which is being developed in conjunction with British Aerospace as a follow-on from that company's Thunderbolt design. The MSA 3.1 is guided by an automatic command-to-line-of-sight system using a digital coded laser link to the missile with a stabilised sight and auto-tracker that follows a flare at the base of the weapon. Upon firing, the missile is initially boosted out of its launcher-container to a point clear of the gunner where its solid propellant rocket motor can cut in to increase its speed to a maximum of 1300 m/s (or Mach 3.9).

The nose of the missile contains the gyro package, thermal battery, motor ignition delay unit, command link detector, receiver and decoder units, guidance command processing unit and the single kinetic energy warhead with a tungsten annular cutter.

Flight control is achieved by lateral thrusters with all guidance and control systems utilising digital electronic circuits. The Single Shot Kill Probability is assessed at 0.75. Shelf life of the system is 10 years.

#### Variants

Multiple launcher versions are planned for use on a tripod, a soft-skin vehicle (jeep) and a wheeled APC.

#### SPECIFICATIONS

TYPE	two-stage, high velocity low altitude
LENGTH	
missile plus launch tube	1.580 m
missile	1.500 m
DIAMETER	
missile	0.060 m
WEIGHT	
complete system	23.0 kg
missile at launch	12.4 kg
GUIDANCE	automatic command-to-line-of-sight (ACLOS)
MAX SPEED	1300 m/s
MAX ENGAGEMENT RANGE	6000 m
MAX INTERCEPT RANGE	5000 m
MIN RANGE	150 m
REACTION TIME	
after target acquisition	2 s
TIME TO RELOAD AND FIRE	6 s

**Status:** Development phase. Owing to the current financial situation of the two parent companies it is believed that no work on this missile is at present being carried out.

**Manufacturer:** ORBITA SISTEMAS AEROSPACIAS SA, Rodovia dos Tamoios, KM 4, PO Box 191, 12231 São José dos Campos-SP, Brazil.

## CHINA, PEOPLE'S REPUBLIC

### CPMIEC Low Altitude Surface-to-air Missile System

#### Development/Description

CPMIEC is currently developing a semi-active radar homing manportable SAM system for the Chinese Armed Forces. Designed for use by a crew of two, the weapon has an integral radar illuminator as part of the launcher assembly.

Propulsion is by a rocket ramjet which gives the weapon a maximum range capability of around 8000 m. The maximum engagement altitude limit is to be approximately 5000 m.

The system should complete its development programme by the end of 1991 with initial production and deployment starting in 1993-94.

**Status:** Development.

**Manufacturer:** Chinese state factories with export marketing carried out by China Precision Machinery Import and Export Corporation (CPMIEC), 17 Wenchang Hutong Xidan, Beijing, People's Republic of China.

Telephone: 895012/8311804

Telex: 22484 CPMC CN

### CPMIEC HN-5 Series Manportable Anti-aircraft Missile System

#### Development

The HN-5 is a product-improved version of the Soviet SA-7 'Grail' manportable surface-to-air missile system which is fully described later in this section.

The current production model, the HN-5A, is a further enhanced variant which is capable of making tail-on engagements against jet aircraft or head-on engagements against propeller-driven aircraft and helicopters under visual aiming conditions. The weapon has seen combat use in a number of regional conflicts.

The main improvements of the HN-5A (Strela-2M equivalent) over the original HN-5 (Strela-2 equivalent) include a greater detection range of the IR homing seeker (made possible by providing cooling to the IR detector), reduced susceptibility to IR background sources such as bright clouds by the incorporation of a background noise rejection device into the IR seeker and a more powerful HE warhead.

Transfer of HN-5 component technology has been made to Pakistan for use in the production of that country's Anza manportable/vehicle-mounted SAM system (qv entry in this section).

#### Description

The system consists of a launch tube which serves as an aiming device and launcher as well as a carrying case, a grip-stock firing unit (designated SK-5A) mounted under the forward part of the launcher which provides launch information and ensures correct firing of the missile and, lastly, a thermal battery mounted on the forward part of the grip-stock to provide power.

The 13 kg missile itself is composed of four sections: the infra-red seeker section which is fitted with both cooling and background noise rejection devices; the control actuator which contains a gas generator; the warhead and fuze and the rocket motor with rear fins attached. The infra-red seeker is designed to detect the thermal radiation emitted from the target and converts this into missile steering commands to guide the missile by proportional navigation to an intercept point.



The China Precision Machinery Import and Export Corporation also offers the CH-3A integral test and measuring vehicle based on a 6 × 6 cross-country chassis to complement the HN-5 as well as a training system.

The CH-3A integral test and measuring vehicle has a target simulation table with an IR source attached, an integral tester and a self-contained power unit.

The training system includes a tubed dummy missile and firing unit for use in operating, aiming and firing practice; a re-usable battery; a monitor score recorder and a moving target simulator.

#### Variants

The HN-5C designation is used to describe a vehicle-mounted HN-5 system. The first shown was a HRB-230 (4 × 4) cross-country vehicle with a forward control fully enclosed cab which contains the fire control electronic equipment. To the rear of the cab is a pedestal on which a bank of four HN-5 or HN-5A missiles in the ready-to-launch position are mounted either side. Between the two banks of missiles is the fire control system which consists of an infra-red tracker, a rangefinder and a TV camera. Detecting and tracking the target and launching the missile can be accomplished either manually or automatically.

Although the prototype system is mounted on an HRB-230 truck, it can be mounted on other chassis as it only weighs 2000 kg. Eight reserve missiles are carried besides the eight missiles in the ready-to-launch



*The HN-5C is essentially an HRB-230 (4 × 4) truck chassis, on the rear of which is mounted a pedestal with four HN-5A SAMs either side*

position. Evaluation trials of the HN-5C were completed in June 1986 but it is understood that production has yet to start.

The main roles of the system can be summarised as follows: protection of mechanised units; air defence for forward units and air defence for high value targets such as airfields.

During the 1987 Paris Air Show a model of the WZ 523 (6 × 6) armoured personnel carrier was shown fitted with the HN-5C launcher system on the vehicle's roof. This has turret elevation limits of -2 to +80°, a traverse of 360° and a total system weight of 2100 kg. The crew is two with the maximum effective missile range stated as 4200 m between altitude limits of 50 and 2300 m.

#### SPECIFICATIONS

TYPE	single stage, low altitude
WEIGHT (including launcher)	16 kg
MAX OPERATIONAL ALTITUDE	2300 m
MIN OPERATIONAL ALTITUDE	50 m
MAX SLANT RANGE	4400 m
MIN SLANT RANGE	800 m
MAX SPEED OF TARGET (in tail-on engagements)	260 m/s (950 km/h)
MAX SPEED OF THE TARGET (in head-on engagement)	150 m/s (550 km/h)
REACTION TIME	not more than 5 s
LAUNCHER	manportable single round disposable with grip-stock

**Status:** Production of the original HN-5 is complete and is in service with the Chinese armed forces and North Korea. The HN-5A is in production and in service with the Afghanistan Mojahedin, the Chinese armed forces, Iran, Iraq, North Korea, Thailand and Pakistan. HN-5C is believed to be entering production.

**Manufacturer:** Chinese state factories with export marketing being carried out by China Precision Machinery Import and Export Corporation, 17 Wenchang Hutong Xidan, Beijing, People's Republic of China.  
Telephone: 895012/8311804  
Telex: 22484 CPMC CN



*Chinese gunner taking aim with HN-5A manportable SAM system*

## EGYPT

### Sakr Eye Low Altitude Surface-to-air Missile System

#### Development

The Egyptian Army used the Soviet supplied Strela-2/Strela-2M SA-7 'Grail' manportable low altitude surface-to-air missile for many years but for a number of reasons Egypt can no longer obtain spare parts or replacement missiles from the Soviet Union.

In the late 1970s, a reverse engineered and improved version of the Strela-2M (SA-7b) was placed in production and subsequently called the Sakr Eye (Eye of the Falcon). It is manufactured by Sakr Factory for Developed Industries at Almaza. The weapon was developed with the technical assistance of Thomson-Brandt Industries as prime contractor, Thomson-CSF and SODETEG.

Qualification occurred in 1982 and it was first shown in public in late 1984 with pre-series production commencing in March 1985. Full production started in 1986 following extensive Egyptian Army trials with initial operational capability being achieved in 1987/1988. Egyptian sources indicated that it cost \$180 million to develop Sakr Eye with all funding coming from the Egyptian Defence Ministry.

Sakr Eye was deployed with the Egyptian units assigned to the Coalition forces in the Gulf War of 1991.

#### Description

In general, the method of operation is similar to the Soviet Strela-2 series which is fully described later in this section. The information provided here is from Egyptian sources who also claim that the system is more reliable than the original Soviet weapon.

The Sakr Eye system comprises two main components; the missile itself and the grip-stock. The missile is transported and launched from an expendable launch tube which is made of glass fibre and is fitted with two aiming sights positioned on the left forward side, an acquisition indicator lamp and a thermal battery mounted under the front which has sufficient power for 40 seconds. The thermal battery can be replaced in the field if required.

The missile is a fire-and-forget type and consists of an infra-red (IR) homing head, guidance and control, warhead and propulsion sections. The grip-stock combines the firing mechanism and the logic circuits and when attached to the launch tube carries out the firing sequence and authorises ejection of the missile in either the manual or automatic modes. Once a target has been engaged, the launcher tube is discarded and the grip-stock attached to a new launcher.

In the absence of an integrated IFF system a typical target engagement sequence is as follows: the gunner acquires the target and aligns the weapon using the open sight and then selects either manual or automatic firing mode; audio and visual cues are given to the gunner to indicate when the target is within the weapon's engagement envelope. The trigger is then squeezed according to the selected mode and the missile is ejected from the launch tube by a small rocket motor. Then, after a short delay, the booster accelerates the missile until the sustainer motor is ignited to propel it to the target. If a target is not encountered within 16 seconds Sakr Eye destroys itself. Homing is by means of a passive infra-red seeker which was developed by Teledyne and is more sensitive than the original. The HE warhead is detonated by a contact fuze that also provides for graze initiation of the warhead.

The Sakr Eye ammunition container has two missiles fitted with thermal batteries plus two spare batteries while the grip-stock container has one grip-stock. It takes 10 seconds to be prepared for action and can engage aircraft travelling at a maximum speed of 280 m/s in a pursuit or flying at a maximum speed of 150 m/s head on. Successful trials have also been carried out with Sakr Eye fitted with the US CA-563 optical sight. This incorporates increased magnification ( $\times 3$  with a  $22^\circ$  field-of-view) with advanced sighting techniques that include a direct computer sight digital interface with the missile, so that positive acquisition and confirmation of specific target lock-on can occur.

The optical magnification is incorporated to improve identification at extended ranges. Light Emitting Diode (LED) cueing is provided to indicate system status such as uncaged seeker or an out-of-tolerance condition. A night vision module can also be incorporated into the CA-563 optical sight.

Optional equipment includes a Thomson-CSF PS-340 IFF unit, which is attached to the right side of the launcher with the interrogator electronics unit hanging on the operator's belt, and a night vision sight.

The Egyptian Army Sakr Eye is normally operated by a three-man team comprising the commander, gunner and wireless operator with a long wheelbase Jeep (4  $\times$  4) light vehicle carrying two missile teams.

#### Variants

#### Pedestal-mounted Sakr Eye

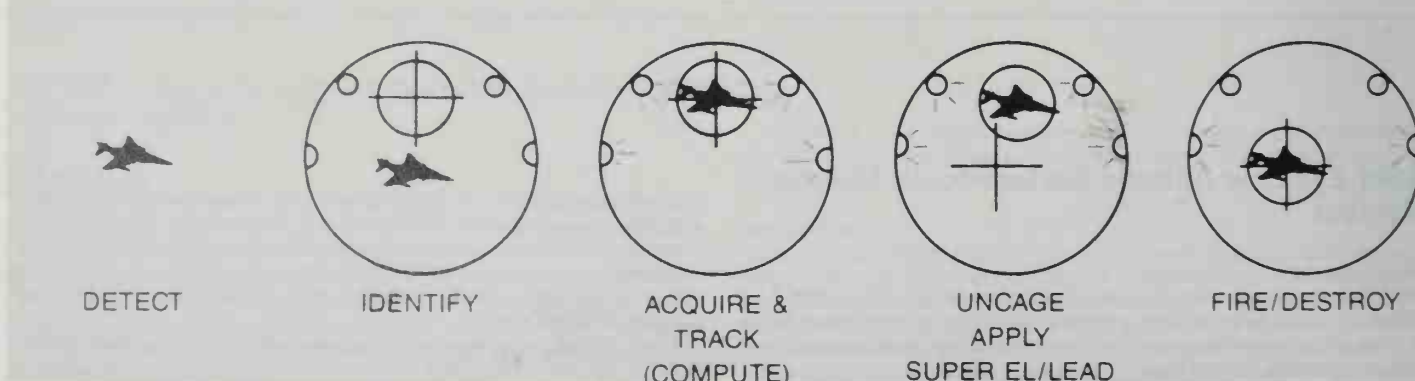
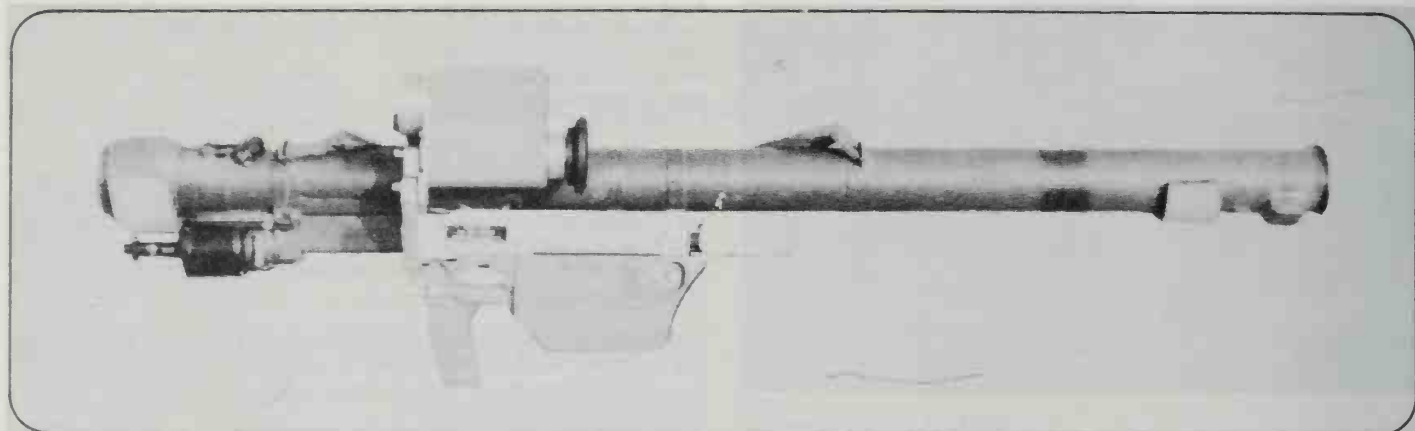
In addition to the standard manportable version the prototype of a pedestal-mounted version has been built and installed on a Jeep. Both ship-launched and helicopter-mounted versions have also been proposed.

#### M113A2-mounted Sakr Eye

The Dassault Electronique Sinai 23 twin 23 mm self-propelled air defence system mounted on an M113A2 chassis is also armed with Sakr Eye surface-to-air missiles, details of which are given in the *Self-Propelled Anti-Aircraft Guns* section.

#### SPECIFICATIONS

TYPE	two-stage, low altitude
LENGTH OF MISSILE	1.4 m
DIAMETER OF MISSILE	0.072 m
WEIGHT OF MISSILE	9.9 kg
WEIGHT OF LAUNCHER	5.1 kg
WEIGHT OF COMPLETE WEAPON	
without CA-563 sight	15 kg
with CA-563 sight	18 kg
PROPULSION	solid fuel booster and solid fuel sustainer rocket
WARHEAD	HE smooth fragmentation with contact and graze fuzeing
MAX EFFECTIVE RANGE	4400 m
MAX EFFECTIVE ALTITUDE	2400 m
MIN EFFECTIVE ALTITUDE	50 m (150 m for a helicopter)
LAUNCHER	manportable single-round disposable with grip-stock
RELOAD TIME	6 s



Sakr Eye SAM fitted with CA-563 optical sight (top) with typical target engagement sequence (bottom)





**Status:** In production. In service with the Afghanistan Mojahedin and Egyptian Army.

**Manufacturer:** SAKR Factory for Developed Industries, Heliopolis, Cairo, Arab Republic of Egypt, POB 33.  
Telephone: 963 239/962 227/965 252  
Telex: 92175—92770 CERVA UN

*Sakr Eye SAM system fitted with night sight and IFF system*

## FRANCE

### Matra Mistral SATCP Low Altitude Surface-to-air Missile System

#### Development

In 1977 a technology group formed by the French Joint Chiefs of Staff and the Délégation Générale pour l'Armement (DGA, French Weapons Procurement Authority) began a study of different short-range gun and missile point defence surface-to-air systems to meet a tri-service requirement for a Very Low Level Air Defence (VLLAD) system. By 1979 the study had been narrowed to the procurement of a new third generation missile system to be known as the *Sol-Air-Très Courte Portée* (SATCP, surface-to-air very short-range) and an operational programme index was established that year by the Direction des Engins/Délégation Générale pour l'Armement (Missile Division of the French Weapons Procurement Authority) to develop a weapon common to all the three services.

In March 1980 an evaluation trial was held to examine the proposals put forward by five competing firms. These were quickly narrowed down to the projects proposed by Matra, Aerospatiale and Thomson-Brandt and in September that year, following further technical and feasibility studies, Matra was named as the firm responsible for developing and producing the SATCP weapon system.

On 1 December 1980 the development contract for the basic man-portable tripod-launched version was placed with the firm naming Matra as the prime contractor and the Société Anonyme de Télécommunications (SAT, for the homing head), Société Européenne de Propulsion (SEP, for the rocket motor), Société Nationale des Poudres et Explosifs (SNPE, for the solid propellants), SAFT (for the thermal batteries) and Manurhin (for the warhead, safety arming device and missile container-launcher tube) as the main subcontractors.

Test firings were started in 1983 and the last of the 37 scheduled launches of what has been named the Mistral by Matra were completed in March 1988. The first production systems were delivered to the French Army and French Air Force during late 1988. The French Army requires 500 launchers and some 5000 missiles in the SATCP and AATCP versions while the French Air Force needs some 400 SATCP launchers and 4000 missiles.

Current French Army deployment is likely to group the SATCP Mistral launchers in three Corps-level air defence support regiments. These will each deploy a number of batteries that will comprise four to six sections, each of six launchers and a Thomson-CSF Samantha alerter system. All sections will normally adopt a triangular field configuration with a pair of launchers at each apex of the triangle, approximately 2.5 km from the other two pairs.

The three Force d'Action Rapide (FAR) divisions, the 4th Airmobile, 11th Parachute and 27th Alpine, will each have their own SATCP launchers equipped with an integral Thomson-LMT IFF device but not linked to a Samantha. The remaining two FAR divisions, the 6th Light Armoured and the 9th Marine Infantry, were each to have a battery of mobile Santal systems but this plan has now been abandoned because of financial constraints. It is probable that these units will be equipped with either additional man-portable SATCP firing posts supported by radar-equipped vehicles or single- or twin-round vehicle-mounted systems.

The French Air Force will use its SATCP launchers for defence of its airfields.

During the Gulf War the entire air defence of the French 'Daguet' Division units on the move was assigned to Mistral systems.

#### Description

The Mistral system comprises the missile in its container-launcher tube, the vertical tripod stand, a pre-launch electronics box, a daytime only sighting system and the battery/coolant unit. A FLIR thermal sight of Thomson-TRT Défense Caliope or THORN EMI manufacture for night-time firing and an IFF interrogation system may be added.

The whole of the basic assembly can be broken down into two 20 kg loads—the containerised missile and the pedestal mount with its associated equipment for carriage by the missile team commander and the gunner respectively. In operational use the system will normally be transported in a light vehicle to the deployment area where it will be man-packed to the firing site by the team.

The missile itself is a slim two-stage cylindrical type with a booster motor to eject it from the launch tube and a sustainer rocket motor to accelerate it to its maximum speed of Mach 2.6. Flight control is exercised by two pairs of movable canard control surfaces located in the weapon's front region. The 2.95 kg HE-fragmentation warhead uses 1 kg of explosive and layers of tungsten balls to achieve increased penetration of the target surface and is fitted with both contact and proximity fuzes to ensure detonation. The Matra Manurhin Défense proximity fuze is an active laser type and has a 1 m precise cut-off distance for use against oncoming or very low level targets. This is an advantage over other types of proximity fuzing which are prone to causing premature detonation due to false target returns.

The cooled passive infra-red (IR) seeker is derived from technology used on the Matra R550 Magic 2 air-to-air missile programme and has a multi-element sensor with digital processing of incoming signals in both the 3-5  $\mu\text{m}$  IR and ultra-violet (UV) regions of the spectrum. This results in a considerable enhancement of the seeker's sensitivity (almost 3.5 times that of the Magic 2) and allows a non-afterburning jet combat aircraft to be acquired at ranges of 6000 m or so and light combat helicopters with reduced IR signatures at ranges of 4000 m or more. In both cases the



*Matra Mistral SATCP missile being launched during trials with booster motor falling away and sustainer motor cutting in*

incoming target angle does not matter as the seeker head can move through  $\pm 38^\circ$  with a narrow field-of-view after lock-on.

An IR transparent magnesium fluoride pyramidal-shaped seeker cover was used so as to appreciably reduce the drag factor normally found at the upper end of the speed range with more conventional cover shapes. This increases the Mistral's manoeuvring capabilities considerably during the terminal phase of the flight, up to the point where it can tackle targets that use 7-8 g evasive manoeuvres.

In combat, the team commander is in charge of liaison with the section fire control centre, identifying the target and ordering the engagement. The gunner then carries out the firing sequence of target acquisition, system lock-on and firing.

At a launch site the firing post is erected first, using its adjustable legs on terrain with a gradient of up to 12 per cent, to level both the attached height-adjustable gunner's seat and the two-handed firing grip. The latter is fitted with a safety lever to avoid accidental operation of the seeker activation lever, a homing head unlocking button to unlock the seeker from a target which is not to be engaged, a seeker activation lever to initiate battery power, a detector cooling and missile gyroscope spin-up button and, lastly, a firing trigger.

The missile in its container-tube is then fitted together with the battery/coolant unit, the sighting device and the pre-launch electronics box. The box carries out the following function during an engagement: it determines the search field and sensitivity of the seeker using the target data derived from the head looking at the aiming point, then, it either automatically rejects it as a false target or confirms it as valid by calculating target correction information for the launch. The battery/coolant unit supplies the electrical power required by the missile before its launch and supplies the coolant necessary to cool the detector cells of the seeker head for lock-on. Once initiated the unit operates for a period of 45 seconds and then has to be replaced which takes a short time to do. It takes approximately 60 seconds to assemble the Mistral system in the ready-to-fire state at a firing site.

The target can be designated in one of three ways: by the team commander, using information passed over a radio net from an off-site observation network or visually, by himself, using binoculars; via information passed to the firing post's azimuth alignment display from a module connected to the section fire control system; or lastly, by the gunner himself using his own sighting system.

Once a target is designated in azimuth the gunner acquires it in elevation with his  $\times 3$  magnification telescope and begins tracking it. All the aiming data is continuously displayed luminously via a clear collimator system which allows the gunner to follow the pre-launch sequence and assess the target's future azimuth and elevation lead angles whilst at the same time tracking the target. He then releases the safety lever and engages the seeker activation lever. This causes the battery/coolant unit to energise and release the detector coolant. After two seconds the system is sufficiently stabilised for the seeker to lock-on to the target and feed its data to the pre-launch electronics box which checks it in the manner described previously. If a validated target is signalled and is within range then the gunner depresses his firing trigger. This causes the SNPE SD double-base extruded propellant booster motor to ignite which accelerates the missile to a muzzle velocity of 40 m/s. Before the entire missile emerges the motor burns out in order to protect the gunner from blast effects. Once free of the launch tube and in its coasting phase the weapon's wraparound tail fins and control surfaces fully deploy. At 15 m from the launcher the booster motor falls away and the 2.5 second burn composite fuelled sustainer motor fires to

accelerate the missile to its maximum speed. The weapon is then guided to the target's exhaust plume by the onboard passive IR/UV homing system whereupon in its immediate vicinity the missile adopts a final forward correction to its flight profile so as to pass close to/hit the target thus activating its warhead. Maximum total flight time possible is 12 seconds (including the 2.5 second sustainer motor burn period). As soon as a round is fired the expended launch tube is discarded and a new one fitted in approximately 10 seconds. Total engagement time from firing sequence initiation to weapon launch can be less than five seconds without early warning of a target and around three seconds if a warning is provided. This allows a single firing post to undertake multiple engagements of targets if required.

A total of 78 light cross-country vehicle-mounted (TRM 2000 or ACMAT VLRA) Thomson-CSF Samantha alerting systems are to be ordered by the French Army for use with the Mistral SATCP air defence sections.

A Samantha shelter-system consists of a Strategèmes data processing system, a PR4G secure combat radio transmission system and a Thomson-CSF TRS 2630P Griffon upper E/F-band radar, with a coherent frequency-agile solid-state emitter and dual-frequency digital pulse-compression receiver mounted within a high gain planar antenna array. The radar has a range of 19.7 km against aircraft/helicopters flying at speeds of 40-850 m/s and uses specific horizontally polarised emissions to monitor for hovering helicopters out to a range of 11 km. For the Gulf War five to six systems were mounted on VAB armoured vehicles.

Samantha is designed to be the first level in the French Army's projected three-level hierarchical Command, Control and Alerting (C<sup>2</sup>A) airspace management network known as MARTHA (*Maillage Antiaérien des Radars Tactiques contre Hélicoptères et Avions*). It can also be used with other missile systems such as Santal and Roland and, if required, will be able to take over control of additional firing platforms from other missile sections whose alerting system has been damaged or destroyed by enemy action.

#### Variants

#### ALAMO Light Vehicle-mounted System

The basic single-round Mistral launcher system has been adapted as the ALAMO (*Affût Léger Anti-aérien MObile*) to fit on light vehicles such as the Peugeot-Mercedes jeep, the FL-500 Lohr all-terrain vehicle, the VLRA ACMAT 4  $\times$  4 light truck and the Matra Poncin all-terrain vehicle. This version has been sold to Cyprus for use on light (4  $\times$  4) trucks.

#### ALBI Lightweight Twin-round Vehicle-mounted System

The lightweight Mistral twin-round vehicle-mounted retractable turret-mounted ALBI (*Affût Léger BImunition*: twin munition light mounting) system is designed for use on light armoured tracked or wheeled vehicles such as the Panhard VBL or SMS VAB to protect both units on the move and vital points (VPs). The IFF and night sighting system options can also be fitted.

#### ATLAS Lightweight Twin-round Launcher System

The Mistral twin-round ATLAS (*Affût Terrestre Léger Anti-Saturation*: Advanced Twin Launcher Anti-air Strikes) is designed for use as either a ground or vehicle mount to protect vital points.

It is derived from the ALBI system and comprises a portable launcher operated by a single man, with two ready-to-fire rounds and a set of firing controls similar to those used on the ALBI.

When used on a vehicle it is possible to dismount the system and quickly configure it for the ground role.

#### SANTAL Armoured Vehicle Turret System

For armoured vehicles, the six-round ready-to-fire all-weather Santal turret version has been developed (see *Self-Propelled Surface-to-Air Missiles* section for a full description).

#### AATCP Air-to-air System

For air-to-air use the Mistral becomes the *Air-Air Très Courte Portée* (AATCP, air-to-air very short-range) missile which uses up to four 70 kg two-round groups of missiles on weapons pylons with an internal electronics box to arm helicopters. The French Army is buying it for its Gazelle armed helicopters using a helmet sight or a stabilised sight for target designation. It has also been tested on the McDonnell Douglas Helicopters AH-64A Apache and is due to arm the French version of the HAP/HAC Tigre. Deliveries of an initial 30 systems to the French Army were to be made in 1992, but due to the Gulf War the programme was accelerated and a number of AATCP equipped Gazelles were used by the French Rapid Reaction Force deployed to Saudi Arabia.



Matra Mistral SATCP system deployed in the Middle East by French Forces during the 1991 Gulf War



## SADRAL Naval System

For naval use, it becomes the 1500 kg all-weather six-round *Système d'Autodéfense Rapproché Anti-aérien Léger* (SADRAL, light short-range anti-aircraft self-defence system) for use on surface ships of all sizes. This version has been adopted by the Finnish, French and Abu Dhabi navies.

## Simbad Lightweight Twin-round Naval System

This is a navalised lightweight twin-round launcher designed primarily for installation on various types of smaller vessels, logistic vessels and support ships to provide them with a degree of autonomous anti-aircraft self-protection.

The Simbad system can be fitted to any type of 20 mm cannon mounting and has been ordered by Norway and France (28 launchers, with deliveries beginning in 1992).

## Mygale Air Defence System

Mistral has been adopted for use with the Mygale low level short-range co-ordinated air defence system, a full description of which appears in the *Self-Propelled Surface-to-Air Missiles* section of this book.

## Platoon Mistral Command Centre (PMCC)

The PMCC was first shown at the 1991 Paris Air Show and is designed to be used with Mistral SATCP or ATLAS firing units to defend the rear areas of infantry, artillery or Vital Point units. It optimises the attrition rate of attacking aircraft, even during saturation raids, and considerably reduces the overkill.

The system is based on existing equipment and comprises:

- (a) a surveillance and fire control radar with IFF
- (b) a command post station for one or two operators
- (c) a co-ordination terminal built into each SATCP or ATLAS firing unit
- (d) a communications network to transmit both voice and data in TDMA
- (e) a command system to communicate with the next higher command echelon.

The complete system (with the exception of the co-ordination terminals) is built into a small, highly mobile air transportable wheeled vehicle.

## SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	
missile	1.81 m
container-launcher tube	1.85 m
DIAMETER	
missile	0.0925 m
WING SPAN	0.19 m
WEIGHTS	
missile (launch)	18.4 kg
container-launcher (with missile)	21.4 kg
PROPULSION	solid fuel ejector rocket motor with solid fuel sustainer rocket motor
GUIDANCE	infra-red/ultra-violet passive homing
WARHEAD	2.95 kg HE-fragmentation with contact and active laser proximity fuzes
MAX SPEED	Mach 2.6
MAX EFFECTIVE RANGE	4-6000 m depending upon target type
MIN EFFECTIVE RANGE	300 m
MAX ALTITUDE	4500 m
MIN ALTITUDE	15 m
LAUNCHERS	manportable or vehicle-mounted single-round disposable, vehicle-mounted twin-round disposable

**Status:** Series production started in 1989, with more than 10 000 rounds on order, in service with or being evaluated by some 20 countries worldwide. Available details are: Europe - Belgium (SATCP system in use, with 714 missiles ordered for army in November 1988 in a contract worth BFr3.5 billion, with further 300 missiles on option); France (initial order for 2300 missiles placed in March 1988, being used by army, navy and air force in



Close up of ALBI system mounted on VAB (6 × 6) chassis with two Matra Mistral surface-to-air missiles in ready-to-launch position



Panhard VBL (4 × 4) light AFV with ALBI system in retracted position and two additional Mistral SAMs on forward part of roof in reserve



Matra Mistral surface-to-air missile system being launched from the ATLAS system during trials in France

SATCP, SANDRAL, SIMBAD and ATAM configurations); Finland (for navy in SIMBAD configuration); Italy (a proposed 75 per cent licensed production agreement for 450 SATCP launchers and 4500 missiles to be built by Ital-Missile Group, comprising SNIA-BPD, OTO Melara and Selenia. First deliveries expected early 1990s); Spain (order to be placed for SATCP) and Norway (for naval vessels ordered 1990); Middle East - Abu Dhabi (SANDRAL system for navy); Cyprus (SATCP and ALAMO systems for National Guard); Qatar and Saudi Arabia (100 SATCP launchers and 700 missiles); Asia - Singapore (SATCP) and Malaysia (SATCP); Africa -

Gabon (Mygale Aspic) and Kenya (FFr600 million contract for ALBI systems awarded 1990 for delivery 1990-94); South America - Chile (SATCP) and one undisclosed customer for Mygale Aspic.

**Manufacturer:** Prime contractor and system integration Matra. Military Branch, B.P.1, F-78146 Vélizy-Villacoublay Cedex, France.  
Telephone: (3) 946 96 00  
Telex: MATRA 698.077 F

## JAPAN

### Toshiba Keiko Low Altitude Surface-to-air Missile System

#### Development

In 1979 the Japanese Defence Agency (JDA) authorised its Technical Research and Development Institute (TRDI) to develop a novel type of manportable low altitude surface-to-air missile system that would have a unit cost of less than 10 million yen, and be considerably more accurate than contemporary weapons currently in service with the Japanese Ground and Air Self-Defence Forces.

Following the allocation of nine billion yen in the FY88 Defence Budget, responsibility for the programme was transferred from the TRDI in February 1988 to the Toshiba Corporation, with the final development phase completed during 1990. The first operational deployments are expected in 1992-93.

Demonstration rounds using the system technology were evaluated by the US Army in 1986.

#### Description

The missile is believed to be of standard configuration using separate current technology booster and sustainer rocket motors. The homing system,

however, is of a dual-mode imaging type which uses both infra-red and visual light region guidance wavelengths. All the operator has to do is to lock the head onto the target whereupon a high resolution charge coupled device (CCD) 'memorises' its appearance and causes the weapon to follow an all-aspects attack flight profile which is extremely resistant to any defensive countermeasures that may be employed.

Maximum engagement range will be between 3000 and 5000 m.

#### Variants

In FY90 the JDA requested £4.4 million to initiate development of a mobile Keiko system. The launcher will be mounted on a four-wheel drive Toyota Land Cruiser together with a radar and a fire control system. Total development time is estimated to be three years with first procurement by the Japanese Ground Self-Defence Force taking place in FY93.

**Status:** Development prototypes.

**Manufacturer:** Toshiba Corporation, 1-1, Shibaura 1-chome, Minato-ku, Tokyo 105, Japan.  
Telephone: (03) 245 3050

## PAKISTAN

### Anza Low Altitude Surface-to-air Missile System

#### Development/Description

The Anza (Lance) manportable SAM system was developed under the auspices of the Pakistani Military Research Laboratories. Approximately 70 per cent of the missile is of indigenous design with the remainder, believed to be the infra-red seeker head, achieved with Chinese technology transfer from the HN-5 programme (qv).

By 1990 all components for the weapon were made in Pakistan. The effective range limits are stated to be 500-5000 m.

#### Variants

At the 1989 Pakistan Day Joint Services Parade in Rawalpindi, the Pakistan Army displayed a number of locally modified FMC M113 APCs fitted with an air defence missile launcher/gun system on the rear decking.

Power operation is provided for the elevation and traverse of a combined mounting installation with a four-tube Anza missile launcher module and a twin 14.5 mm Type 75-1 heavy machine gun module. The gunner is believed to be seated within the confines of the APC to operate the system.

Locally built armoured cross-country chassis have also been produced with Anza four-round launcher systems.

**Status:** Production. In service with the Pakistan Army (in manportable, M113 and locally built self-propelled versions).

**Manufacturer:** Pakistan state factories.



*Pakistani Anza system with four Anza SAMs in ready to launch position mounted on armoured cross-country chassis*



## ROMANIA

### SA-7b (Strela-2M/9K32M) Low Altitude Surface-to-air Missile System

#### Development

The Soviet Strela-2M (Soviet industrial index number 9K32M) manportable missile system, currently being licence built by the Romanian state armaments industry, is specifically designed to destroy visually acquired aerial targets such as helicopters, aircraft or RPVs. Against jet aircraft and RPVs moving at speeds up to 260 m/s the best engagement aspect is a pursuit flight profile, while for propeller driven aircraft and helicopters at speeds of up to 160 m/s a pursuit or head-on engagement is possible. The system can also engage and destroy hovering targets provided they are within the launch envelope and emitting sufficient heat energy for the seeker to lock-on to.

The effectiveness of the system increases if a remote target acquisition system, for example a radar and target movement indicator, is used.

#### Description

The Strela-2M missile system consists of the following elements (shown here with Soviet industrial index numbers):

- (1) 9M32M missile
- (2) 9P54M disposable launch tube
- (3) 9P58 grip-stock launching mechanism
- (4) 9B17 disposable thermal battery power supply unit.

The 9M32M missile comprises four separate sections:

- (1) nose section - with a single channel passive infra-red transparent seeker unit (designated TGS: *teplovaya golvka samonavedeniya*) and autopilot that receives the target signal from the TGS and creates the guidance commands that are sent to the missile's control section
- (2) control section - with the missile control vanes; the angular speed sensor (designated DUS: *datchik uglovyykh skorostey*) which senses the angular speed of the missile's airframe oscillations, and translates them into signals used to stabilise the missile on its desired flight trajectory; a solid-propellant gas generator; and an onboard power supply, which powers the control vanes and comprises a turbine driven by diversion of exhaust gases from burning propellant charge located in the solid-propellant gas generator
- (3) warhead section - with a 1.15 kg HE chemical energy (0.37 kg HE charge) fragmentation warhead and detonating system. The latter comprises a remote-control arming device, contact and graze fuzing circuits and a self-destruct mechanism, and can only be activated following missile launch
- (4) propulsion section - with a launch booster that provides the missile with its initial 28 m/s velocity to drive it out of the launch tube with an angular rotation speed of  $28 \pm 5^\circ/\text{s}$ . Once clear of the gunner (approximately 5-6 m away), and with the four rear fins deployed, the first grain of the sustainer motor fires and starts to accelerate the missile up to its maximum flight speed. Between 80 and 250 m further away the second propellant grain ignites. A total of 4.2 kg of solid propellant fuel is carried.

The 9P54M glass fibre launch tube is used to transport, aim and launch the missile. A 9P58 grip-stock is attached to it to act as the launching mechanism. Fitted to this is the disposable 9B17 thermal battery power unit, which supplies both 22 V and 40 V DC to the appropriate grip-stock electronics, missile electronics and missile seeker head. Following a 1-1.3

second activation period the battery will operate for a further 40 seconds before it has to be replaced.

The complete missile system is capable of operating at a relative air humidity of 98 per cent between  $-40$  and  $+50^\circ\text{C}$ .

#### SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	
missile (fins folded)	1.440 m
launch tube	1.500 m
DIAMETER	
missile	0.072 m
WEIGHT	
total launcher assembly	
in firing position	15 kg
in travelling position	16 kg
launch tube	3 kg
grip-stock plus battery	1.95 kg
battery	0.66 kg
missile at launch	9.85 kg
PROPULSION	solid fuel booster and solid fuel sustainer rocket motor
GUIDANCE	single channel passive infra-red homing
WARHEAD	1.15 kg HE-smooth fragmentation with contact and graze fuzing
AVERAGE MISSILE SPEED	500 m/s
MAX FIRING RANGE	
receding target	4200 m
approaching target	2800 m
MAX TARGET ENGAGEMENT SPEED	
receding target	260 m/s
approaching target	150 m/s
MAX EFFECTIVE	
TARGET ALTITUDE	2300 m
MIN EFFECTIVE	
TARGET ALTITUDE	50 m (can be down to 15 m but missile may be seduced by horizon and ground radiative heat effects)
MISSILE SELF-DESTRUCT TIME	
AFTER LAUNCH	14-17 s
SYSTEM DEPLOYMENT TIME	10 s
MISSILE PREPARATION TIME	
(AFTER ACTIVATION OF BATTERY)	5 s
BATTERY LIFETIME AFTER	
ACTIVATION	40 s
LAUNCHER	manportable single-round disposable with grip-stock

**Status:** Production. In service with the Romanian Army and offered for export.

**Manufacturer:** Romanian state factories.

## SWEDEN

### Bofors RBS 70 Series Low Altitude Surface-to-air Missile System

#### Development

In late 1967 the Swedish Army's Commander-in-Chief gave a special Air Defence Committee the assignment to review the country's air defence requirements and recommend what equipment should be developed or bought to meet them.

On the given economic and strategic grounds the Committee chose a combination of Saab JA-37 Viggen interceptors and short-range missile systems. The latter had to be cheap enough to be procured in large numbers yet still be able to operate under very adverse ECM conditions. The Committee also recommended that the chosen system should replace the 20 mm cannon and General Dynamics Redeye (known locally as the Rb69) shoulder-launched SAM at the brigade level and the Bofors 40 mm and 57 mm anti-aircraft guns at the divisional level.

After reviewing all the alternatives available, a development contract for one of the systems studied by the Committee, the RBS 70, was placed with Bofors in mid-1969. It was intended at this stage to procure only the missile in its container-launcher tube, the control system and the sight and stand, with target detection being carried out visually.

However, the studies carried out by the Committee and later by the Commander-in-Chief of the Army, showed that a more effective system would be produced if a search radar and IFF system were included. Therefore, in mid-1972 development contracts were also placed with SATT Elektronik AB for the PI-69 IFF system and for the RBS 70 and with LM Ericsson for its PS-70/R search radar (now known as the Ericsson Radar Electronics AB PS-70/R Basic Giraffe radar).

The first delivery of RBS 70 systems for trial purposes was made in late 1973 with user trials conducted between 1974 and 1975. In a three-phase evaluation programme the Swedish Army fired more than 100 complete

test rounds fitted with telemetry heads. In 1975 the programme was completed satisfactorily and in June of that year the first production orders were placed for the Rb70 missiles, sights, stands and PI-69 IFF sets. The first order for production of Basic Giraffe radar sets was not placed until 1978. The first production day-only RBS 70 sets were delivered to Swedish Army training units in 1976 with the first operational units being formed the following year. The first production radar sets were delivered in 1979.

Currently, each of the Swedish Army's 11 Type 77 infantry, nine Type 66 and four Norrland brigades have an air defence company equipped with the RBS 70 manportable SAM system. Each company consists of an HQ element (with four cargo and one tow truck(s)), three missile platoons (each with three RBS 70 launcher stands) and a radar platoon (with two Saab-Scania Type 40 4 x 4 cross-country vehicles mounting PS-70/R Basic Giraffe radar sets).

In the late seventies Bofors completed development of the RBS 70 system by introducing a bigger observing angle for the missile laser receiver that enlarges the engagement envelope by between 30 to 50 per cent depending upon the tactical situation. Protection of the four Swedish Army armoured and mechanised brigades is provided for by similar strength air defence companies to the infantry units but equipped with the improved version using converted lkv-102 and 103 armoured tank destroyers as the Lrvbv 701 launch platform (see *Self-Propelled Surface-to-Air Missiles* section for full details). The Swedish Army systems are to be modernised in 1993-98.

To complete the RBS 70 family Bofors was awarded a development contract in 1984 by the Swedish Defence Procurement Administration (FMV) for the RBS 70M (M=Mörker, Swedish for night) day/night missile system. Contracts were also placed with Ericsson Radar Electronics AB for complementary search and tracking radars and a thermal imaging system for the weapon and to Hägglund Vehicles for the conversion of its Bv 206 articulated tracked vehicle as the fire unit.

Now known by the designation RBS 90, the first production systems were delivered late in 1991 (qv entry in *Static and Towed Surface-to-Air Missile Systems*).

#### Norwegian Army Low Level Air Defence System

A modified version of the Giraffe has been developed under a contract placed in 1983 for the Norwegian Army. Known as the Norwegian Army Low Level Air Defence System (NALLADS) project, the updated Giraffe 50 AT (All Terrain) radar contains a specially designed data-processing unit and is known under the Norwegian designation NO/MPY-1 radar system. It is installed on a Bv 206 tracked vehicle with the power generator and communications equipment in the front car and the radar and command and control units in the trailer car. The G-band radar and back-to-back IFF antenna can be raised up to a height of 7 m on an extendable arm. The frequency-agile radar provides automatic location, pop-up handling, identification and evaluation of threats and can handle up to 20 targets simultaneously with automatic track initiation on its two operator stations (each of which is equipped with a 482.6 mm full colour raster scan display). The derived data can be sent to terminals at each one of up to 20 RBS 70 launch stations through a specially developed communications system. Up to three NALLADS can be linked together to defend an extremely large area. The software for the system was developed by Ericsson in conjunction with Nordic Electronic Systems while the weapon-control terminals come from Siemens (Norway). The first prototype system was delivered to the Norwegian Army in 1987 with a SEK615 million contract placed in 1989. Deliveries will start in 1992.



The Ericsson Giraffe 50AT search radar and anti-aircraft C<sup>3</sup>I system on a Bv 206 all-terrain vehicle which has been selected as part of the Norwegian Low Level Air Defence System (NALLADS)



Bofors RBS 70 SAM deployed in firing position

Target detection performances are: 70 km range/7000 m altitude against a 10 m<sup>2</sup> target; 50 km range/5200 m altitude against a 3 m<sup>2</sup> target; 37.5 km range/4000 m altitude against a 1 m<sup>2</sup> target and 22.5 km range/2200 m altitude against a 0.1 m<sup>2</sup> target.

#### Description

The basic RBS 70 missile is a two-stage solid propellant rocket motor powered type. It is never removed from its container launcher tube when in the field but once fired the tube is discarded. Both impact and active laser proximity fuzes are fitted with an HE-fragmentation warhead that is surrounded by numerous tungsten pellets. The proximity fuze is set for short-range activation so as to avoid premature detonation during operations close to reflecting surfaces such as ice, snow and water. For very low altitude targets, such as helicopters flying nap-of-the-earth flight profiles or behind natural obstacles such as trees, it can be disabled before launch by means of a switch on the gunner's left-hand aiming grip, so that the weapon actually needs to hit the target with its contact fuze in order to score the kill. The shape charge can penetrate all aerial armoured targets as well as light armoured vehicles and surface targets.

In addition to the essentially smokeless Imperial Metal Industry's sustainer rocket motor, the missile body also houses a receiver unit which senses deviation from the laser line-of-sight and a small computer which converts these deviation signals into guidance pulses that command the missile to automatically follow the centre of the laser beam. Maximum engagement altitude is around 4000 m whilst the minimum altitude is effectively ground level.

The Mk 1 is essentially the same as the basic missile but uses a laser guidance sensor unit which increases the rearward field-of-view to 57° from 40°. This considerably enlarges the available engagement envelope.

The Mk 2 is markedly different internally but remains the same in terms of overall size and weight. The electronics have been considerably miniaturised in order to fit a larger motor and warhead. The new sustainer increases both the missile velocity profile and the maximum range and altitude (up to 7000 m as opposed to 6000 m of the other round types against slow moving targets and from 3000 to 4000 m altitude). A slightly higher maximum velocity is reached and once in the coasting phase the velocity decreases more slowly, so that when the missile reaches its maximum range it is flying slightly faster than the earlier round types. The basic firing unit comprises two major parts; a stand and the sight. Each constitutes a one-man pack with a third team member carrying missiles in their container-launcher tubes. The IFF equipment, if used, forms another portable pack as does the target data receiver terminal which is used in conjunction with the Giraffe search radars.

For an engagement the tubular stand assembly is removed from its carrying harness and the three legs unfolded and roughly levelled by adjustments to one of them. The operator's seat is then unfolded from the vertical central tube and the gyro-stabilised sight, power supply, IFF unit and launcher-container missile tube attached. All the electrical connections are made to these units, the operator's headset and the data receiver terminal if present. A well trained crew will take only 30 seconds to complete all these procedures.

When the Basic Giraffe PS-70/R truck-mounted G-band pulse Doppler radar is networked with the launcher unit, before operations can begin, a prismatic compass is set up behind the vehicle pointing at a mirror located on the edge of the radar's cabin roof. The angle between true north and the radar reference direction is read from the compass and set into the radar by means of a switch on the control panel to ensure that the Position Plan Indicator (PPI) scan is orientated to the north. A point at least 20 km to the south and west is then chosen on the map of the area and the radar's position is read and its co-ordinates, relative to the chosen point, are inserted on the control panel by a thumb wheel. Each firing unit attached to



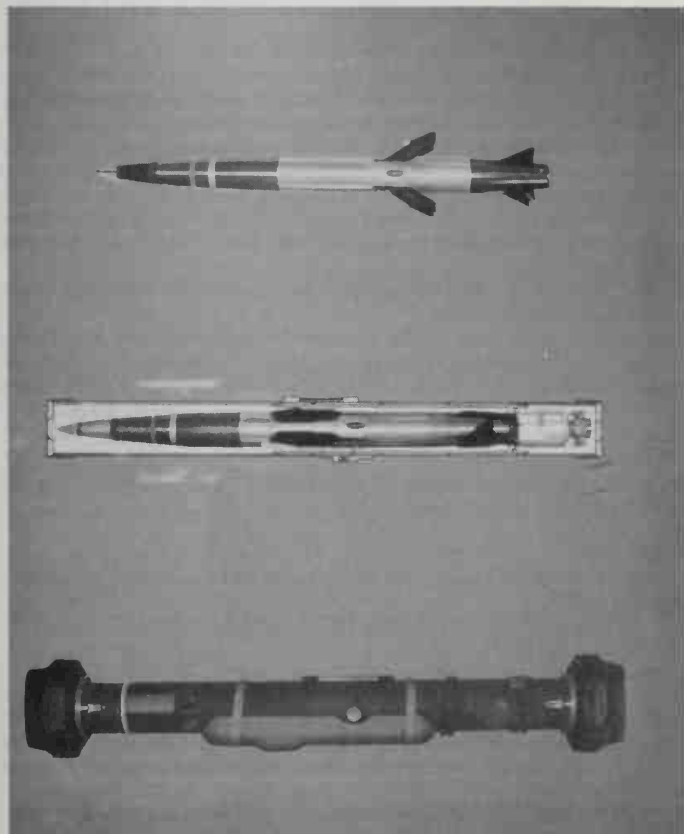
the radar is then also orientated to true north by prismatic compasses at each site and the relative positions of the radar and firing units established on a common grid purpose for command and control reasons. For defence of an area containing a number of high value targets the firing units are deployed around 4000 to 5000 m apart thus allowing a company to defend an area of approximately 200 km<sup>2</sup>.

The radar has MTI facilities and is fitted with an antenna that is elevated on a hydraulically operated mast to a height of 12 m. The operating cab houses three operators who detect and track targets on the digital PPI with another man plotting the air situation as updated by higher echelons on a map which is used by the commander as the basis for his orders.

A radar search is initiated on receipt of a radio report from the higher air defence echelons which indicates a potential target is approaching. The maximum detection ranges of 3 m<sup>2</sup> and 0.1 m<sup>2</sup> radar cross-section targets, at speeds between 30-1800 m/s, are 28 km and 12 km respectively. Maximum instrumented range is 40 km whilst altitude coverage is from ground level to 10 000 m. Up to three can be handled simultaneously between the radar's altitude limits of very low level up to 10 000 m. The target's speed, course and direction is then passed up to a maximum of nine firing units by radio or cable link to the data receivers as required by the radar vehicle commander. With the radar vehicle's aid the firing unit can engage to the maximum range of the missile.

The target data receiver unit computer takes the information sent, applies a parallax correction, displays the required angle of traverse and range to the target on a small screen and transmits an acoustic signal to the gunner who slews his sight and launcher assembly using two aiming handles until he hears a pulse tone on his headset. This indicates the sight is aligned with the approaching target in azimuth and the gunner then starts to search in elevation until he acquires it. Once the target is in missile range, indicated again by the target data receiver, the gunner fires the weapon by depressing a button with his left thumb. The latest target data receiver has a built-in threat evaluation providing priority of the assigned targets and also presenting first and last time to fire.

The laser guidance unit is activated and a Bofors booster motor on the missile is ignited to propel it out of the tube. For operator safety the motor cuts out before the end of the missile leaves the tube. The booster motor is jettisoned at a point several metres from the muzzle and the round's four centre body fins and four rear cruciform control surfaces unfold. The sustainer motor ignites and the guidance receiver on the missile starts to sense the modulated laser guidance beam. The onboard computer then translates these signals received into commands for moving the electrically operated control surfaces. Once at maximum velocity the sustainer cuts out and the missile continues on course in its coasting mode. To ensure a hit the gunner has only to keep the target in the middle of the crosshairs of his sight by using a thumb joystick.



RBS 70 missile in flight, cutaway of missile in launcher/transport tube and missile in launcher/transport tube as carried in field

If no search radar is available an observation post has to be established to provide early warning. The gunner then has to search for the target himself. When he has slewed the system onto the rough bearing of the target he releases the weapon's safety-catch, activates the electronics for missile launch some five seconds later and commences fine aiming with a reticule sight. The IFF equipment, if fitted, is automatically activated at the same moment and this transmits an interrogation signal. If a friendly response is received the firing circuit is overridden and visual signal lamps in the aiming sight indicate that this has happened. The gunner then discontinues the action and resets the safety device. The  $\times 7$  magnification sight he uses for the fine aiming has a 9° aperture. The range is gauged by means of a graticule with a head-on fighter-sized target which is indicated as being in range when it appears to be bigger than half the central gap in the graticule. If it is twice as large as this space then it is too close for effective engagement. Once the gunner is satisfied that the conditions are correct he launches the missile, maintaining his aim to the missile impact by guiding the gyro-stabilised optical sight with his thumb joystick.

Reloading takes less than 10 seconds and the empty tube is discarded. The padded end-caps of a new container-launcher are removed and this is hooked onto the stand and secured by a lever which also connects the electrical contacts for the pre-launch power supply to the missile and the firing signal from a battery in the sight unit.

## Variants

### RBS 70 VLM

There is a vehicle-launched version of the RBS 70 system available under the designation RBS 70 VLM. The launcher platform can be a light all-terrain vehicle with the stand assembly mounted at the rear. This version is also offered on the Panhard VCR (6  $\times$  6) APC, Bv 206 tracked vehicle and Cadillac Gage V-200 series APC with one missile in the ready-to-fire position and six to eight others in reserve.

### RBS 70 SLM

The system has also been adopted for use on small naval vessels. In this guise it is known as the RBS 70 SLM, either in a basic version or in a containerised version.

### RBS 70/M113A2 Vehicle-mounted System

In response to a mid-1980s requirement from the Pakistan Army for an RBS 70 installation to defend mechanised units, Bofors adapted its VLM system for use with the FMC M113A2 tracked APC. A full description of the system is given in the *Self-Propelled Surface-to-Air Missiles* section.

### RBS 70 Modular Concept

The RBS 70 Modular concept is intended for integration with either vehicle- or ship-mounted air defence systems as an add-on or new-build addition. The integrated system can then be tailored to the tactical requirements depending upon the weaponry and selected sensors of the vehicle or ship.

In the former case the weapon system can be fitted on either light cross-country or heavy armoured vehicle designs with Bofors providing the RBS 70 missile launcher modules (one to four, depending upon fit, 500  $\times$  450  $\times$  1750 mm in size with each containing two ready-to-fire missiles and weighing 80 kg in the light vehicle module version and 100 kg in the heavy vehicle module version), the missile control unit (300  $\times$  250  $\times$  250 mm in size and weighing 10 kg), a freon container (300  $\times$  200  $\times$  200 mm in size and weighing 8 kg including the container), missile sequencer unit (350  $\times$  300  $\times$  200 mm in size and weighing 8 kg) and guidance beam transmitter.

All the movable parts are mounted on a servo-controlled pedestal or turret. Depending upon the complexity required, the customer can then integrate these Bofors modules with various types of his own chosen modules/systems as deemed necessary for the system's tactical role. For example a high technology approach by a purchaser might involve networking the vehicle system to an external surveillance system for target detection and assignment, so that it can be operated either manually or automatically for the engagement of the assigned target.

The co-partner would then provide for the vehicle the purchaser's own choice of laser rangefinder, TV and/or FLIR sensor modules, pedestal/turret servo drive systems, fire control computer, automatic tracking system and operator control panel with monitor facilities. The sensors and Bofors guidance beam transmitter assembly would then be mounted on a joint structure for aiming at the target.

### RBS 70 Clip-on Night Device

To increase the RBS 70 operational capacity beyond its daylight engagement capabilities Bofors Aerotonics in co-operation with Swedish Ordnance has developed a clip-on night aiming device for attachment to the front of the day sight unit. This weighs less than 20 kg (including an integral battery power pack) and utilises an infra-red scanner unit for target imaging.



RBS 70 VLM based on Land Rover (4 × 4) chassis with one RBS 70 SAM in ready-to-launch position and reserve missiles carried in rear of vehicle

THORN EMI Electronics are supplying the scanner and electronic control unit, similar to the Class I common modules supplied for the RBS 56 BILL ATGW. The thermal picture generated from the unity magnification equipment of the sight is injected directly into the front end of the day sight.

### Bofors RBS 90 SAM system

Details of this are given in the *Static and Towed Surface-to-Air Missiles* section.

### Bofors BAMSE (Bofors Advanced Medium-Range Surface-to-Air Evaluation)

Details of this are given in the *Static and Towed Surface-to-Air Missile Systems* section.

### RBS 70/REPORTER

The day-only RBS 70 systems have been interfaced with the Dutch Hollandse Signaalapparaten REPORTER radar system in place of the Giraffe set. This uses a portable operations room shelter-mounted on the rear of any 1½ ton military vehicle, a generator unit and a 5 m extendable radar antenna mounted on a two-wheel trailer towed by the radar truck.

The 2D I/J-band radar is fitted with an integrated IFF system and has a 40 km detection range on targets flying between 15 and 5000 m. An MTI facility is fitted and the system can track up to 12 targets automatically from a 20 km range. The information derived is then routed automatically via a one-way data transmission system to all the firing units in the field to ensure their positions are not revealed. An unlimited number of such units can receive this data. The total time from target detection by the radar operator to the actual reception of an alarm at a firing unit can be as little as four seconds.

It is believed Indonesia uses this variant.



Bofors RBS 70 SAM installed on a Cadillac Gage V-200 (4 × 4) Commando APC chassis as used by Singapore Air Force

### SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	
missile	1.32 m
container-launcher (with end caps)	1.745 m
DIAMETER	
missile	0.106 m
container-launcher	0.152 m
WING SPAN	0.32 m
WEIGHTS	
Mk 1 missile (at launch)	16 kg
Mk 2 (at launch)	16.5 kg
container-launcher (with Mk 1 missile)	26 kg
(with Mk 2 missile)	26.5 kg
stand (with carrying harness)	25 kg
sight with pads and carrying harness	35 kg
PROPULSION	solid fuel booster and solid fuel sustainer rocket motor
GUIDANCE	modulated laser-beam riding
WARHEAD	Mk 1, 1 kg HE-fragmentation with contact and active laser proximity fuzing Mk 2, larger with fragmentation, shaped-charge and similar fuzing
	supersonic
MAX SPEED	
MAX RANGE	
Mk 1	
high speed targets	5000 m
low speed targets	6000 m
Mk 2	
high speed targets	6000 m
low speed targets	7000 m
MIN RANGE	about 200 m
MAX ALTITUDE	
Mk 1	3000 m
Mk 2	4000 m
MIN ALTITUDE	ground-level
LAUNCHER	manportable or mobile single round trainable stand

**Status:** In production. By 1991 total production of the RBS 70 system amounted to well over 1000 launchers and 10 000 missiles with Norway being the largest customer. In service with the following countries:

#### Argentina

A small quantity has been delivered to the Marine Corps.

#### Australia

Early in 1985 the Australian Army selected the RBS 70 as its Very Low Level Air Defence System (VLLADS) and a contract was placed with Bofors for the supply of 60 launchers and support items. A Memorandum of Understanding (MoU) was also drawn up between Australia and Sweden which provides for assurances on non-interrupted product support for the system. It also allows Australian industry to participate in the development and production of the next generation missile system. In addition, Australian industry would become involved in the manufacturing of locally designed high technology products for sale by the Bofors worldwide marketing organisation.

The first contract was valued at SEK87 million with additional orders subsequently being placed.

The RBS 70 is used in the 16th Air Defence Regiment with Rapier systems: a Rapier battery (for example 110th) has three troops each with one launcher and a Blindfire radar whilst an RBS 70 battery (for example 111th) has one troop of five RBS 70 launchers.

#### Bahrain

The Bahraini Army purchased RBS 70 launchers and missiles in 1979 with the first deliveries being made in 1980.

#### Iran

A number of RBS 70 launchers and missiles were apparently obtained in the mid-1980s.

#### Ireland

The Irish Army purchased four RBS 70 launchers in the late 1970s.

An order for a Basic Giraffe radar mounted on a 4 × 4 truck chassis was placed in 1985. This was delivered in 1986 and uses AN/VEC-46 radios for data transmission and AN/PRC-77 radios to receive the target data at the missile post positions. The alternative to the radio net is a standard telephone cable link.

#### Indonesia

A number of RBS 70 launchers have been delivered for use by the Indonesian Army. The Giraffe radar system is also in service.



**Norway**

Following a Norwegian Army competitive evaluation in the late seventies for a manpads missile system a contract was placed worth SEK400 million for 110 RBS 70 launchers and 27 Basic Giraffe radars. These were used from 1981 onwards to reorganise the air defence batteries of six field brigades with three Basic Giraffe radars, 18 RBS 70 launchers and twelve 20 mm light anti-aircraft guns each. The first radars were delivered in 1982.

In 1984 a second manpads evaluation contest was held for a system to re-equip the rest of the field brigades. The RBS 70 again won and a SEK700 million contract was placed with deliveries to take place between 1987 and 1990. The contract also involved a long-term maintenance agreement between Bofors and the Norwegian Ministry of Defence and the participation by Norsk Forsvarsteknologi (NFT, formerly Kongsberg Vaapenfabrikk) in manufacturing some of the electronic components of the system and undertaking the final assembly and testing of the sights.

The contract also contained an option which has been taken up for additional systems for use by the Norwegian Coastal Defence Force. Most of these systems have already been delivered.

In April 1988 Norway awarded a further SEK500 million contract to Bofors for the Mk 2 missile as the third phase of its RBS 70 procurement programme for its Army and Coastal Defence Force. The missiles are scheduled for delivery between 1990-92 with the contract including options for additional missile batches as required.

In September 1989 Norway awarded Bofors an SEK800 million plus contract for RBS 70 launcher systems and Mk 2 missiles to replace the 40 mm L/60 Bofors anti-aircraft guns used as the main component of the Norwegian Air Force air defence network around its airbases. Delivery began in 1991 and is to continue through to 1994.

**Pakistan**

In 1986 Pakistan ordered missiles and RBS 70 launchers with Basic Giraffe radar systems. These were delivered from 1986 onwards and include M113A2 APC installations. Pakistan is now making certain parts of the RBS 70 SAM system under licence.

**Singapore**

The Singapore Air Force operates one squadron of RBS 70 launchers that are carried on Cadillac Gage Commando V-200 (4 × 4) APCs. The Singapore Army also uses a number of the portable launchers.

The Basic Giraffe radars of the Army Air Defence Artillery Unit have been locally mounted on modified Mercedes-Benz (6 × 6) truck chassis. The conversion work was carried out by Singapore Automotive Engineering (SAE).

**Sweden**

The Swedish Army deploys a large number as described in the development section of this entry. In December 1988 the Swedish Armed Forces placed a SEK200 million contract for Mk 2 missiles.

**Taiwan**

A small number (believed to be 20) systems/missiles have been acquired via clandestine sources for use in developing an indigenous laser-guided manportable SAM (qv Taiwan following this entry).

**Tunisia**

In 1979 the Tunisian Army ordered 60 RBS 70 launchers and 12 Basic Giraffe radar systems which were delivered in 1980-81.

**United Arab Emirates**

In 1979 Dubai placed an order for a number of RBS 70 launchers and missiles which were delivered from 1980 onwards.

**Venezuela**

A number of RBS 70 launchers have been delivered for use by the Venezuelan Army.

**Manufacturers:** Swedish Ordnance (previously Bofors), S-69180 Bofors, Sweden

Telephone: (0) 586/8100,

Telex: 732 10 bofors,

Fax: 46 586 58145

PS-70/R Giraffe, PS-90 Giraffe 75 and PS-91 radars

Ericsson Radar Electronics AB, Surface Sensors Division

S-431 84 Mölndal, Sweden.

Telephone: (46) 31 671000

Telex: 20905 ericras

Fax: (46) 31 873891

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## TAIWAN

### CSIST Low Altitude Surface-to-air Missile System

**Development/Description**

The Chung Shang (or Sun-Yat-sen) Institute of Science and Technology (CSIST) is developing a manportable laser-guided low altitude SAM system for use by all the branches of the Taiwanese Armed Forces.

It is expected to be physically similar to the Swedish RBS 70 system as a small quantity (approximately 20) have been obtained through clandestine sources for evaluation/trials purposes.

**Status:** Development. To be ordered by the Taiwanese Army, Navy, Air Force and Marine Corps.

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## UNION OF SOVIET SOCIALIST REPUBLICS

### SA-18 Low Altitude Surface-to-air Missile System

**Development/Description**

American sources have indicated the presence of an improved Soviet manportable surface-to-air missile system which has been assigned the

US designation SA-18. Apart from being reported as being in service in field test quantities during 1990 no further information is available.

**Status:** In production. In service with the Soviet Armed Forces.

**Manufacturer:** Soviet state factories.

### SA-16 'Gimlet' Low Altitude Surface-to-air Missile System

**Development/Description**

In the 1987 edition of *Soviet Military Power*, published by the US Department of Defense, it was revealed that the Soviets were fielding a third type of PZRK (*perenosniy zenitniy raketniy kompleks*: portable air defence system) with their armed forces. Given the US designation SA-16 and NATO designation 'Gimlet' the only other information offered was that it was considered to be a highly accurate weapon and was replacing the SA-7 in units on a one-for-one basis. Initial operational date was thought to be 1981.

Known by the Soviets as Igla-1 (Russian for needle), the system comprises a missile in a 9M39 launching tube with a grip-stock launching mechanism and portable battery power unit. Examples have been captured in Angola by UNITA and South African Defence Forces. It is essentially a new system with a changed shape around the shoulder rest (the battery/coolant reserve is canted downward at an angle of about 10° relative to the launcher tube), a frangible nose cap and a modified firing mechanism. The nose is a conical pyramidal shape similar to that on the French Mistral. The system was used by Iraq during the Gulf War and scored most of the manportable SAM kills against Coalition Force aircraft (including four McDonnell Douglas AV-8B Harrier II).



Cutaway of the forward end of the SA-16 (Gimlet) surface-to-air missile system



Guidance is by proportional navigation using the cooled seeker unit. Maximum target bearing angle for a launch is  $\pm 40^\circ$ . System deployment time is 13 seconds and launch time from target acquisition is 5 seconds.

In the Finnish Army the system is called the 86 Igla and is linked to external target acquisition and control systems. These modifications include the use of a locally made infra-red target finder with an automatic search mechanism designed by Altim Control. A fire command unit, developed by the Nokia Group, allows firing instructions to be relayed electronically from the command vehicle to the gunner. This vehicle will be a modified troop transporter and a target location radar will be mounted on a Pasi cross-country vehicle to complete the system set-up. Training on the 86 Igla is being undertaken by the Rovaniemi Air Defence Battalion.

#### Variants

Variants are known to exist, including the Igla-1 (9M313 launching tube) and Igla-1M (9M313-1 launching tube with a 9P515-2 grip-stock).

A Soviet Naval quadruple mounting is known as the SA-N-10 by NATO.

#### SPECIFICATIONS (provisional)

TYPE	two-stage low altitude
LENGTH	1.55 m
DIAMETER	0.80 m
WEIGHTS	
missile	10.8 kg
launcher	4.2 kg
WARHEAD	2 kg HE-fragmentation with contact and graze fuzes
PROPULSION	two-stage solid propellant booster and sustainer
GUIDANCE	cooled IR homing
AVERAGE MISSILE SPEED	570 m/s
MAX EFFECTIVE RANGE	5000 m
MIN EFFECTIVE RANGE	600 m
MAX EFFECTIVE ALTITUDE	3500 m
MIN EFFECTIVE ALTITUDE	10 m
LAUNCHER	manportable single-round disposable with grip-stock

**Status:** In production. In service with Angola, Finland, Iraq, Nicaragua and the Soviet Union.

**Manufacturer:** Soviet state factories.

SA-16 (Gimlet) surface-to-air missile system deployed in the field

## SA-14 'Gremlin' Low Altitude Surface-to-air Missile System

### Development

The PZRK (*perenosniy zenitniy raketniy kompleks*: portable air defence system) Strela-3 (Russian for Arrow) was given the US designation SA-14, NATO designation 'Gremlin', when it entered operational service in 1978.

The 'Gremlin' has replaced the earlier SA-7 series weapons on a one-for-one basis in many front line units such as the organic anti-aircraft missile squads (each of three operators with grip-stocks) of BTR-60/70/80 (8 x 8) equipped Motorised Rifle companies, Soviet Naval Infantry companies and BMD equipped Airborne companies, the organic anti-aircraft missile platoons (each of nine operators with grip-stocks) of BMP equipped Motorised Rifle battalions and Soviet Army and Navy Spetsnaz special forces.

Examples of the SA-14 were captured by the Uniao Nacional para a Independencia Total de Angola (UNITA) movement in southern Angola during the October 1987 Lomba river battles against the MPLA and Cuban mechanised units.

Systems have also been captured in El Salvador by government troops fighting the FMLN guerrilla group. Several El Salvadorian Air Force planes have been lost to SA-14s and the weapon has caused major tactical changes in combat mission flight profiles.

### Description

Compared to the SA-7 series the SA-14 has an uprated rocket motor, a more powerful warhead and a cryogenically cooled passive infra-red homing seeker with proportional guidance so it can deal with both approaching and receding aircraft and other targets manoeuvring at up to 8 g. It is also believed to incorporate IR signal processing to defeat common IR countermeasures such as flares and modulated IR 'hot-brick' type decoys. The missile is similar to the SA-7 but heavier. The grip-stock assembly has a ball-shaped battery at the front in contrast to the rear-mounted can-type battery of the SA-7. The weapon can also be fitted with a passive radio-



A close up of the nose ends of the three missile launchers showing the different sights, battery and coolant assemblies on three launchers. The SA-16 (right) has a conical nose cone, and a battery/coolant assembly mounted below and at an angle from the launcher tube. The SA-14 (centre) has a flat nose cover, similar to the SA-7, and a battery/coolant assembly mounted parallel to the launcher tube. The SA-7 has a quite different battery/coolant assembly below the launcher tube.





SA-14 'Gremlin' manportable surface-to-air missile system captured in Angola by UNITA forces late in 1987

frequency direction-finder antenna system. Maximum effective engagement range against an approaching target is said to be 4000 m and a receding target 6000 m. The minimum effective range is said to be 600 m. The maximum and minimum effective engagement altitudes are above and below that of the SA-7.

#### Variants

A Soviet Navy quadruple-round launcher, similar to the SA-N-5 system, is known as the SA-N-8 by NATO.

#### SPECIFICATIONS (provisional)

TYPE	two-stage low altitude
LENGTH	
missile	1.4 m
DIAMETER	
missile	0.075 m
WEIGHTS	
missile	9.9 kg
launcher	6.1 kg
PROPULSION	solid fuel booster and solid fuel sustainer rocket motor
GUIDANCE	cooled infra-red homing



This illustration shows the launcher tube assemblies for the three missiles without the battery/coolant assemblies fitted. SA-16 'Gimlet' is on the right, SA-14 'Gremlin' is in the centre and SA-7 'Grail' left.

The similarity between the SA-7 and the SA-14 launchers is quite marked, while the SA-16 launcher differs in many aspects, including different flip-out aiming sights which are arranged more on the side of the launcher

WARHEAD	2 kg HE-fragmentation with contact and graze fuzing
MAX SPEED	600 m/s
MAX EFFECTIVE RANGE	6000 m
MIN EFFECTIVE RANGE	600 m
MAX EFFECTIVE ALTITUDE	5500 m
MIN EFFECTIVE ALTITUDE	10 m
LAUNCHER	manportable single-round disposable with grip-stock

**Status:** In production. In service with Angola, Cuba, Czechoslovakia, El Salvador (FMLN guerrilla group), Finland, Hungary, India, Iraq, Jordan, Nicaragua, Poland, Soviet Union, Syria and UAE (Abu Dhabi Royal Guard).

**Manufacturer:** Soviet state factories.

## SA-7 'Grail' Low Altitude Surface-to-air Missile System

### Development

Development of the PZRK (*perenosniy zenitniy raketniy kompleks*: portable air defence system) Soviet Military name Strela-2 (Russian for Arrow, Soviet factory index number 9K32, US designation SA-7a, NATO designation 'Grail' Mod 0) was begun in 1959 by the Tupolev OKB-134 design bureau at Tushino in order to provide a manportable passive infra-red homing surface-to-air missile system capable of engaging the enemy's battlefield support aircraft and helicopters. Development was completed in 1965 and the SA-7a (Soviet factory index number for missile 9M32) entered Soviet Army service in 1966. Due to its fairly primitive 1.7-2.8  $\mu$ m wavelength lead sulphide seeker head with a 1.9° field-of-view and 6°/s tracking rate it was only effectively able to engage a target when it was fired from directly behind at the very hot exhaust area. This tail-chase situation resulted in it only being able to engage aircraft flying at less than 925 km/h with the preferred target being one flying at 462 km/h or less. This early type uncooled seeker was also easily saturated by false targets as it did not have any filter system to screen out spurious heat sources. Thus the missile seeker could not be pointed within 20° of the sun (as it would home on to this rather than the target) or fired at an elevation of less than 5° (as it could pick up geothermal heat from sun-baked rocks on the ground and home on that). The acquisition range varied, depending upon aircraft type and background, from 600 to 2100 m. It could also be saturated by solar reflection from clouds and go wildly off course. These faults also made the Strela-2 very vulnerable to countermeasures such as infra-red decoys and flares and made it unable to engage low-flying targets. In order to rectify these faults the Soviets fielded the Strela-2M, (Soviet factory index number 9K32M, US designation SA-7b, NATO designation 'Grail' Mod 1) in 1971 which included a more sophisticated seeker with a filter to exclude spurious and countermeasure heat sources and an improved warhead to give greater uniformity in the fragmentation pattern. Although still a tail chase weapon the SA-7b (Soviet factory index number for missile 9M32M) can be

fired from up to 30° either side of the target's tail and still have a good chance of hitting it. The Strela-2M can also be used with a small passive radio frequency (RF) antenna fixed to the front of the operator's helmet. This picks up the emissions from aircraft radars and radar altimeters and feeds a set of small headphones so as to provide the gunner with an audio warning of the approach of an aircraft and its rough direction.

For the Soviet Spetsnaz special forces the Strela-Blok version of the Strela-2M was developed. This uses a special launcher device in place of the grip-stock with an integral timer that allows the system to be emplaced near the likely flight paths of enemy aircraft and helicopters in rear areas and at airbases. Once the time delay ends an acoustic sensor is activated which is gated to a preset noise level. When this is achieved the missile is launched.

In the mid-seventies an improved version of the Strela-2M was produced. This, known by the US designation SA-7c and NATO designation 'Grail' Mod 2 (possible Soviet factory index number system 9K32M1, missile 9M32M1), has a new grip-stock with a vertical handhold and a small paddle assembly just behind the thermal battery. The paddle arrangement is a more sophisticated RF detector to replace the previous helmet-mounted system.

The first recorded combat use of the SA-7a was in 1969 during the 1968-70 Egyptian-Israeli War of Attrition when around 100 or so firings caused a small number of Israeli jet fighter-bombers to be damaged in the jet pipe area. At the same time as this happened the SA-7 was given to the North Vietnamese Army to counter the American mass use of helicopters, however, it was not used widely in combat until the 1972 invasion of South Vietnam when the weapon scored a number of kills against both American gunship and transport helicopters and slow-flying fixed-wing aircraft such as the Cessna O-2 observation plane, the Douglas A-1 Skyraider piston-engined fighter-bomber, the Lockheed C-130 Hercules transport and the Lockheed AC-130 Hercules gunship. During the period 30 March to 30 June 1972 it shot down a total of 10 US and 6 South Vietnamese planes and helicopters. By the end of the American involvement in January 1973 a total of 528 missiles had been fired at US and Vietnamese planes scoring 45 kills (including 1 F-4, 7 O-1s, 3 O-2s, 4 OV-10s, 9 A-1s, 1 CH-47, 4 A-37s,



Close up of SA-7 'Grail' manportable surface-to-air missile system showing trigger arrangement

4 AH-1s and 9 UH-1s) with another six seriously damaged. In the 50 launches against the US Army helicopters, in the period April 1972 to January 1973, 4 AH-1Gs, 1 UH-1H and 1 CH-47A were lost, and casualties would have been higher but for the adoption of various countermeasures. During the first six months of 1973 some 22 SA-7 launches were detected by South Vietnamese aircraft, destroying six planes and three helicopters. In the remaining six months of 1973 and the whole of 1974 another 19 South Vietnamese aircraft/helicopters fell victim to the missiles. From January 1973 through to June 1974 the RVNAF lost 5 A-1, 5 A-37, 1 AC-119K, 3 UH-1, 2 CH-47 and 1 F-5A. In the following year the SA-7 was seen to have spread to all four Military Regions of South Vietnam and was continuing to take a steady toll of South Vietnamese Air Force assets including Cessna A-37 and Northrop F-5 jet fighter-bombers causing the switching of many bombing missions to medium altitude rather than low altitude for which the Air Force had been trained. The weapon was also instrumental in providing air defence to the fast moving North Vietnamese army columns during the last months of South Vietnam's existence in 1975.

However, it was two years prior to this that the SA-7 series saw major action when some 4356 were launched by both Syrian and Egyptian troops against the Israeli Defence Force Air Force over the 19 days of the Yom Kippur War. These scored four confirmed kills (2 A-4s, 1 second-line type and 1 Super Mystere), assisted in the destruction of three other aircraft (1F-4E and 2 A-4s) and caused damage to the tailpipes of 28 others. Of the latter only a few suffered sufficient damage to ground them for longer than a day.

The SA-7 has also seen combat use in the 1982 Falklands conflict (with Argentinian Air Force personnel, no kills), the 1982 Invasion of Lebanon (with Syria), the Gulf War (by both Iraq and Iran), Angola (by the MPLA and Cuban troops against South Africa with 255 fired between 1978-1986 and well over 300 by September 1988 destroying one Impala jet and damaging four other aircraft including a C-47 Dakota), in Nicaragua (by both the Sandinistas, destroying 1 C-123K and 1 DC-6 supply planes operated by covert units, and the Contras, one Mi-8 Hip in 1985, in South Yemen during the January 1986 Civil War, on the Thai-Laotian (destroying 1 Thai F-5E and 1 A-37) and Thai-Kampuchean borders (by Laotian, Kampuchean and Vietnamese forces), along the North/South Yemen border by North Yemen-supported rebels (destroying at least 2 Su-22 'Fitters'), in the 1978 Ugandan-Tanzanian War (with one MiG-17 and 3 'own goal' Xian F-7s lost to Tanzanian Army gunners) and in the Chad region (by Libya, and Libyan supported guerrillas, against French aircraft, with one Jaguar A destroyed).

The relative simplicity of the SA-7 has also resulted in the widespread distribution of the weapon to various guerrilla and terrorist groups throughout the world.

In Soviet service the SA-7 is operated by a team of two. The gunner carries the grip-stock and one missile in a canvas bag while his assistant carries another missile. Motorised Rifle BTR-60/70/80 (8 x 8) equipped, Soviet Naval Infantry and BMD-equipped airborne companies have an organic anti-aircraft missile squad of three SA-7 teams whereas BMP-equipped Motorised Rifle battalions have an organic anti-aircraft missile platoon with nine teams carried in the platoon's three BMPs. The gunner can either stand in the APC hatch or dismount to fire. He normally has up to four additional rounds stowed within the vehicle. The SA-7 has been replaced in Soviet front-line service by the SA-14 'Gremlin' and SA-16 'Gimlet' shoulder-launched systems.

Despite its faults the SA-7 has achieved its design aim of forcing enemy pilots to fly above the minimum radar detection altitude of Soviet-type



Close up of Polish SA-7 'Grail' manportable surface-to-air missile system with Pelangator (Soviet name for an R/F direction-finder) on his helmet

radars which makes them vulnerable to higher echelon air defence systems. In several conflicts it has also had the added effect of causing enemy pilots to adopt new higher altitude weapons delivery tactics and this has resulted in a significant degrading of their bombing accuracy and their capacity to aid ground forces.

#### Description

The system consists of the missile in its green (for operational round) launch container canister (Soviet factory index number 9P54 for the Strela-2 and 9P54M for the Strela-2M), a reloadable grip-stock (Soviet factory index number 9P53 for the Strela-2 with a 24-pin connector and 9P58 for the Strela-2M and a 28-pin connector between it and the canister) and a can-like thermal battery. To operate the system the gunner visually identifies and acquires his target. He then loads a missile in its disposable glass fibre container onto the grip-stock and pointing the launcher at the target he pulls the trigger back to its first stop to start the short-life battery and energise the seeker head's sealed tracker unit. This contains a folded reflective optical system that is sensitive to heat and also acts as a space-stabilised gyroscope to aid missile stability in flight. It takes between four and six seconds to do this and once the seeker is energised and uncovered a red light on the launcher's optical sight is lit. As soon as the infra-red detector cells in the seeker detect the reflection of heat energy from the optical system a green light is activated on the sight and an audible warning is sounded by a small alarm under the rear of the grip-stock near his ear. The operator then depresses the trigger fully and the missile is expelled by the first-stage solid propellant booster motor to reach a speed of 28 m/s. This burns out in 0.05 seconds, before the tail of the missile leaves the tube to protect the operator from being burned. The booster then falls away at a safe distance from the launch position and the four spring-loaded stabiliser tail fins and the two canard control fins at the front deploy as the missile coasts along. Once this operation is complete the solid propellant second-stage sustainer rocket motor cuts in about 5-6 m from the operator and 1.25 seconds into the flight to accelerate the weapon within 1.8 seconds to its maximum speed. The seeker head continually determines the angle of the heat it is reflecting and the onboard guidance system uses this data to resolve the difference between the direction that the head is pointing and the weapon's trajectory by moving the two variable-incidence control fins. Throughout its fuel-inefficient lag-pursuit flight the missile spins in an anti-clockwise direction for stability. The SA-7a has a maximum speed of around Mach 1.13 (385 m/s) and is capable of effectively engaging targets at a slant range of between 800 and 3600 m at altitudes between 50 and 2000 m. The improved SA-7b increased the performance envelope by



using a boosted propellant charge with the same burn time to give a maximum speed of Mach 1.7 (580 m/s) and an average speed of 500 m/s, slant range limits of 800 and 4200 m and altitude limits of between 50 and 2300 m. In both versions the missile warhead contains 0.37 kg of HE and is armed after 45 m of flight. It automatically self-destructs after 14-17 seconds of flight, which in the case of the Strela-2 is some 6000 m plus down range. If this happens close to an aircraft then severe damage can still occur. The helmet-mounted Pelangator RF detection system of the Strela-2M is known to be in service with the Soviet and Polish armies. Training (coloured yellow) and exercise (coloured silver) launch tubes are also available.

#### Variants

The East German Army fielded its own version of a quadruple SA-7 launcher in 1979 for use on the rear of Robur LO-1801A (4 × 4) 1800 kg light trucks. The system, known as *Flugzeugabwehrstartanlage* (FASTA: Air defence launcher assembly), was used to defend rear area positions such as airfields. It was originally a Soviet idea but was first seen in operation on Egyptian vehicles during the 1973 Yom Kippur War. The Soviet Navy deployed a similar system in 1974 on its small combatants, amphibious warfare vessels and auxiliaries. It was given the NATO designation SA-N-5.

In 1981 a Strela helicopter self-defence mounting was seen for the first time with the Soviet Air Force on Mil Mi-24 'Hind' gunship helicopters. This involved the fitting of quadruple Strela-2M launcher arrangements on the helicopter's weapon carriers. Subsequently a two-round version was seen mounted on a Polish Air Force Mil Mi-2 'Hoplite' variant either side of the fuselage. The Yugoslavian Air Force uses a single round Strela-2M launcher on each side of the Type NNH weapon pylons attached either side of its GAMA gunship variants of the licence-built Aerospatiale SA-342L Gazelle helicopter. Air-to-air range of the Strela-2M remains at 4200 m.

Egypt has reverse engineered the Strela-2M under the designation Sakr Eye (qv entry in this section) and China has produced an equivalent system under the HN-5 designation (qv entry in this section). The basic HN-5 (equivalent to the Strela-2) was followed by the HN-5A which is equivalent to the Strela-2M with some further improvements, including seeker cooling to enhance sensitivity.

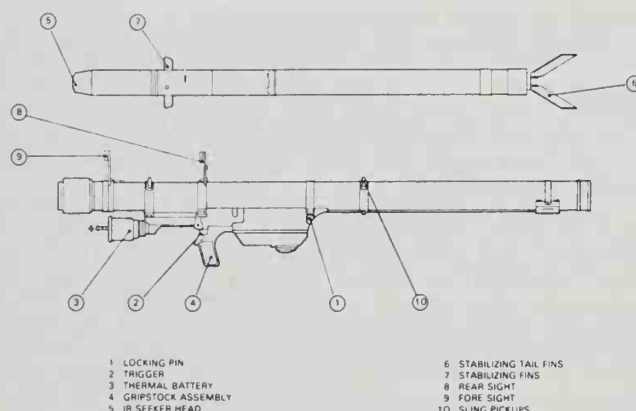
Yugoslavia has produced its own variant, the Strela-2M/A (qv entry in this section), and Romania builds the Strela-2M under licence (qv entry in this section for a full description of this weapon).

#### SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	
missile (fins folded)	1.44 m
launcher	1.50 m
DIAMETER	
missile	0.072 m
launcher	0.1 m
LAUNCH WEIGHTS	
Strela-2	9.2 kg
Strela-2M	9.85 kg
LAUNCHER WEIGHTS	
Strela-2	4.17 kg
Strela-2M	4.95 kg
PROPULSION	solid fuel booster and solid fuel sustainer rocket motor
GUIDANCE	infra-red passive homing
WARHEAD	1.15 kg HE-smooth fragmentation with contact and graze fuzing
MAX SPEED	
Strela-2	385 m/s
Strela-2M	580 m/s
MAX EFFECTIVE RANGE	
Strela-2	3600 m
Strela-2M	4200 m
MIN EFFECTIVE RANGE	
Strela-2	800 m
Strela-2M	800 m
MAX EFFECTIVE ALTITUDE	
Strela-2	2000 m
Strela-2M	2300 m
MIN EFFECTIVE ALTITUDE	
Strela-2	50 m
Strela-2M	50 m (can be down to 15 m but may be seduced by horizon or ground radiated heat)
LAUNCHER	manportable single-round disposable with grip-stock
RELOAD TIME	6 s



SA-7 'Grail' manportable SAM system



Main components of SA-7 'Grail' surface-to-air missile

**Status:** Production of the SA-7 is now considered to be complete. In service with Afghanistan, Algeria, Angola, Argentina, Benin, Botswana, Bulgaria, Burkina Faso, Cambodia, Cape Verde Islands, Chad, People's Republic of China (local version), Croatia militia, Cuba, Cyprus, Czechoslovakia (licence-built from 1972), Egypt (and local version), Ethiopia, Finland (where it is known as the 78-Strela or SAM-78), Ghana, Guinea, Guinea-Bissau, Guyana, Hungary, India, Iran, Iraq, Jordan, North Korea, Kuwait, Laos, Libya, Mali, Mauritania, Mauritius, Mongolia, Morocco, Mozambique, Nicaragua (including SA-7c), Nigeria, Peru, Poland, Romania (qv 9K32M entry this section), Serbian militia, Seychelles, Sierra Leone, South Africa, Somalia, Soviet Union, Sudan, Syria, Tanzania, Uganda, Yemen, Yugoslavia (qv Strela-2M/A entry this section), Zambia and Zimbabwe.

It is also in widespread service with various guerrilla/terrorist groups throughout the world. These include in Europe the Provisional IRA; Uniao Nacional para a Independencia Total de Angola (UNITA), Polisario Front, Sudanese People's Liberation Army (SPLA), Eritrean Liberation Front (ELF), Mozambique National Resistance (MNR), and Northern Armed Forces (FAN) Chad; in the Middle East the Abu Nidal Group, the Palestinian Liberation Army (PLA), the Palestinian Liberation Organisation (PLO), Popular Front for the Liberation of Palestine-General Command (PFLP-GC), Sa'iqa, Al-Fatah, Christian Militia, Druze Militia, South Lebanon Army, Hezbollah, Amal Militia, various Kurdish groups and various Afghan Mojahedin groups; in Central America the Farabundo Marti National Liberation Front (FMLN) in El Salvador; in South Asia the Liberation Tigers of Sri Lanka and in the Far East the Khmer Rouge, the Moro National Liberation Front (MNLF), the New People's Army (NPA) and the Khmer People's National Liberation Front (KPNLF).

**Manufacturers:** Soviet state factories. Licence-built by Bulgarian, Czechoslovakian, Romanian and Yugoslavian state factories. Reverse engineered copies produced by Egypt (qv) and the People's Republic of China (qv).

## UNITED KINGDOM

## Shorts Starstreak Close Air Defence Weapon System

## Development

General Staff Requirement (GSR) 3979 was drawn up by the British MoD following requests from the British Army of the Rhine for an air defence system to supplement the tracked Rapier SAM system then in service, especially in the forward battlefield area. The Royal Armament Research and Development Establishment had already carried out a detailed study that showed that a high velocity missile system rather than a gun or a gun/missile mix was the best solution. GSR 3979 required not only a self-propelled version of the High-Velocity Missile (HVM) but also a three-round lightweight launcher and a single-round manportable launcher.

Originally 11 companies showed an interest in the project, but in the end this was narrowed down to three competitors; British Aerospace, Marconi Command and Control Systems and Shorts. Late in 1984 the British MoD awarded both British Aerospace and Shorts a one year project definition contract valued at £3 million each for the HVM, although each company invested some of its own money as well. Both companies submitted their proposals and detailed costings in October 1985.

The British Aerospace entry was called Thunderbolt and had a single warhead dependent on kinetic energy to destroy the target. The self-propelled version had 12 missiles in the ready-to-launch position with additional missiles carried below under armour protection. The Shorts solution was called Starstreak (in-house project designation S14) and used three individually guided darts which employ both kinetic and chemical energy to destroy the target.

In June 1986 the MoD decided to go ahead with the Shorts Starstreak and in December 1986 awarded them a £225 million contract for the development, initial production and supply of their Starstreak high-velocity missile system in all three versions. The Armoured Starstreak model will be the first to be fielded followed by the lightweight launcher and finally the single round system. Major subcontractors to Shorts on the Starstreak programme are Royal Ordnance Westcott for the rocket motor, Alvis for the Stormer full-tracked APC and Avimo for the gunner's sighting system. Shorts had, however, already started development of an HVM under the company project number S14 following a very detailed analysis of current and future air threats which showed that the major threat of the future would be very fast attacking fixed-wing aircraft and the late unmasking attack helicopter. An HVM was the only type of missile which would enable targets to be defeated before they released their weapons.

By the time they were awarded the contract by the MoD, Shorts had already carried out over 100 test firings of the HVM since 1982 as part of a technology demonstrator programme aimed at minimising risk during the full development phase. The Starstreak HVM is complementary to the British Aerospace Rapier SAM, and the former is deployed more forward than the latter.

Under the British Government's 'Options for Change' Policy, the Royal Artillery will have four air defence regiments of which two will be equipped with Rapier (towed) and two with Starstreak HVM. The British Army based

in the UK and Germany will have one Rapier and one Starstreak HVM regiment with each regiment having three batteries.

## Description

All three versions of the Starstreak will use the same basic missile. There is a separate entry for the Armoured Starstreak variant on the Alvis Stormer chassis in the *Self-Propelled Surface-to-Air Missiles* section. This version also carries a Lightweight Multiple Launcher for dismounted use.

The Starstreak missile is sealed in an environmental container that also acts as the launcher unit. It requires no field testing, as the only launch preparation required is the connection of the re-usable aiming unit.

The missile itself consists of a two-stage solid propellant rocket motor assembly with a payload separation system mounted on the front end of the second stage motor. This supports three winged darts which each have guidance and control circuitry, a high density penetrating explosive warhead and delay action fuzing.

The aiming unit contains all the systems required for the engagement cycle and comprises two separate and detachable assemblies:

- (a) a light alloy casting hermetically sealed optical head with an optics stabilisation system, aiming mark injector unit and aimer's monocular sight. All three of these are used for acquiring and tracking the target
- (b) a hermetically sealed control unit in a lightweight moulded case which contains the power supply unit (with one lithium sulphur dioxide battery pack) and the electronics units required for processing and control. An attached control handle contains the joystick controller, trigger assembly, system switch, wind offset switch and superelevation button.

In combat, the aimer acquires the target in his monocular sight and selects 'system-on' which energises the aiming unit battery supply. A space-stabilised aiming mark is injected into the centre of the field-of-view of the aimer who then tracks the chosen target by moving the launcher assembly so as to maintain the target in coincidence with the aiming mark. This permits lead angles in both azimuth and elevation to be generated and ensures that the missile is brought onto the target at the end of its boost phase.

After this pre-launch tracking phase is completed, the aimer presses the firing trigger which causes a pulse of power to be transmitted from the aiming system power supply to the missile booster unit where it causes the first stage rocket motor to ignite. The Starstreak is ejected from its launch tube by this motor which completely burns out within the length of the container in order to safeguard the operator. The booster accelerates the missile to a high exit velocity while its canted exhaust nozzles impart sufficient roll on the weapon to create a centrifugal force that unfolds a set of flight stabilising fins. The first-stage motor then separates from the main missile body and falls away as the Starstreak emerges from the canister.

At a safe distance from the gunner, and less than a second into the flight, the main second stage rocket motor cuts in to accelerate the missile to an end-of-boost velocity which is in the region of Mach 3 to Mach 4. As the motor burns out, the attenuation in thrust triggers the automatic payload separation of the three darts which, upon clearing the missile body, are independently guided in a fixed triangular formation by their individual onboard guidance systems using the launcher's laser designator beam and a grid matrix.



Latest configuration of the Lightweight Multiple Launcher version of the Shorts Starstreak HVM



Manportable version of Shorts Starstreak HVM showing sighting system





Shorts Starstreak High Velocity Missile out of its canister and showing three manoeuvrable darts each containing a high explosive warhead

The darts ride the laser beam projected by the aiming unit which incorporates two laser diodes. One of which is scanned horizontally and the other vertically to produce the required 2D matrix. Each dart then uses its onboard guidance package to control a set of steerable fins so as to hold its flight formation within this matrix. Separation of the darts also initiates arming of the warheads.

The darts, about 0.45 m long, 0.02 m in diameter and made of dense alloy, rely primarily on their kinetic energy for target penetration, with the impact forces generated activating the delay action fuze mechanism so that the explosive component (more than 50 per cent of a dart's total weight) detonates within the confines of the target for maximum effect.

All the operator has to do after the launch is to continue to track the target and maintain his sight aiming mark on it by use of the joystick. Once the engagement is over the operator discards the empty launch tube and connects a fresh one to the aiming unit. Maximum effective range is around 7000 m which is the maximum distance at which the darts can retain sufficient manoeuvrability and energy to catch and penetrate a modern 9 g manoeuvring target.

As Starstreak does not rely on a heat source for guidance, it can engage targets from all angles including head on. A Single Shot Kill Probability (SSKP) of 0.96 has been mentioned in connection with the system.

The Lightweight Multiple Launcher version consists of three standard Starstreak rounds in a 'traffic-light' configuration and a manportable aiming unit mounted on a traverse head that can be quickly slewed through a full 360°. The system can stand above ground or be sited in a trench.

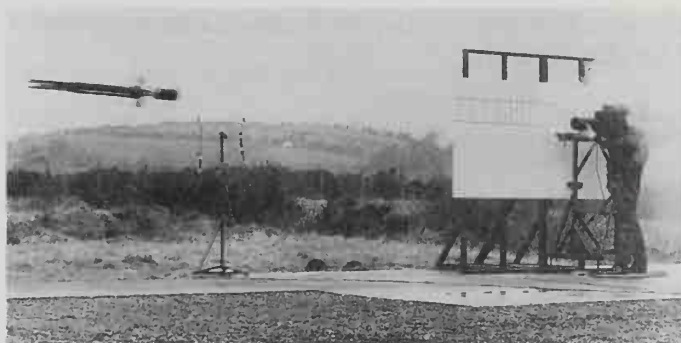
The basic Starstreak HVM is a clear weather system only but target information can come from a number of other sensors such as the THORN EMI Air Defence Alerting Device (ADAD) which was ordered by the British Army in 1987.

In mid-February 1988 Shorts announced that they had signed an Intent to Team Agreement with the Boeing Aerospace Company of Seattle, USA, covering mutual promotion of the Shorts Starstreak High Velocity Missile. Boeing Aerospace has already been selected as the prime contractor for the Pedestal-Mounted Stinger (covered in the *Self-Propelled Surface-to-Air Missiles* section). Under this agreement, the two companies are exploring applications that can complement the Pedestal-Mounted Stinger, more commonly called the Avenger. The first Starstreak firings from an Avenger unit occurred in August 1990.

#### Variants

##### Helstreak

In September 1988 Shorts teamed with McDonnell Douglas Helicopters and Martin Marietta for a weapon integration programme on the AH-64 Apache helicopter for close-range air-to-air engagements. The system, known as Helstreak, will consist of one or more 2-round missile panniers (weighing approximately 50 kg each and similar to that fitted to the Boeing Avenger air defence vehicle) and a guidance transmitter. The pannier to aircraft attachment is by a standard 14 in electronic release unit. The



Shorts Starstreak HVM being fired for the first time in the off-the-shoulder role in 1988. The launch was completed with 100% success

Helstreak is also applicable to other helicopters such as the PAH-2. Other variants being studied are a shipborne system and the use of technology in the US DoD SDI concept.

##### Seastreak

During 1989 Shorts exhibited a shipborne version of Starstreak, known as Seastreak, which is intended to provide a close-in defence against low level strike aircraft and anti-ship missiles.

The complete Seastreak stabilised installation consists of 12 canistered missiles mounted on each side of a continuously rotating sensor unit with elevation and azimuth drives separated from the unit. A synchronous programme of surveillance typically using a K-band surveillance radar and either an electro-optical sensor or a Racal designed M-band millimetric radar as the tracker unit gives coverage against targets approaching from any angle and relays positional data to a below-decks fire control processor which provides threat evaluation in terms of approach speed, crossing rate and weapon allocation function.

The Seastreaks are fired typically one against an aircraft and three in salvo against a missile to give a high hit probability. The complete installation weighs just over 1000 kg and can be installed on all sizes of naval vessel and ships taken up from trade.

In 1991 Shorts displayed the Starstreak pannier for use on its Naval Multiple Launcher system. Two panniers, each containing three missiles, can be fitted to the one man mount.

#### SPECIFICATIONS (provisional)

TYPE	two stage high velocity missile low altitude
LENGTH	
missile	1.397 m
missile in canister	1.397 m
DIAMETER	
missile	0.127 m
missile in canister	0.274 m
WEIGHT	not available
PROPULSION	two stage booster-sustainer solid propellant rocket motor beam riding laser
GUIDANCE	triple kinetic/high explosive submunitions
WARHEAD	About Mach 4 (1364 m/s)
MAX SPEED	7000 m
MAX EFFECTIVE RANGE	300 m
MIN EFFECTIVE RANGE	not available
ALTITUDE LIMITS	manportable single, trainable stand-mounted triple or Stormer APC-mounted octuple with all using disposable containers
LAUNCHER	

**Status:** Entering production. In November 1990 it was announced that the Starstreak programme was being stretched.

**Manufacturer:** Short Brothers PLC, Defence Systems Division, Montgomery Road, Belfast BT6 9HN, Northern Ireland.

Telephone: (0232) 458444

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Fax: (0232) 705293

## Shorts Starburst Low Altitude Surface-to-air Missile System

### Development

The Shorts Starburst Close Air Defence Missile System (in-house project designation Javelin S-15) was developed from the mid-eighties onwards as an advanced unjammable variant of the Javelin manportable low altitude SAM system. Designed to meet an MoD requirement placed on behalf of the British Army, the Starburst maintains all of the proven characteristics of the parent system's airframe and aiming unit but incorporates the laser optical command guidance technology of the high velocity follow-on, Starstreak, to significantly increase the weapon's single shot hit probability.

The first shoulder-launched firing took place in 1986 and development was completed in 1989. This was also the year that the weapon was formally accepted for service by the British Army, with the first deliveries being made. Operational deployment began in early 1990.

Starburst was deployed during operation Desert Storm by 10 (Assaye) Battery, 40th Field Regiment Royal Artillery, where it maintained an operational availability of 100 per cent for all battlefield days during the war.

In its simplest form the Starburst system consists of two units — a single missile in its container-launcher and a clip-on aiming unit. However, its prime application is a three-round system which utilises the Shorts Lightweight Multiple Launcher (LML) to provide both increased firepower and enhanced tracking capability. Depending upon configuration of the LML the Starburst can be used for ground, trench, vehicle or naval applications.

### Description

The Starburst missile consists of a two-stage motor, pre-fragmented blast warhead and dual mode (impact/proximity) capacitance fuze. Twist and steer commands are sent to the forward-mounted steering control surfaces

whilst ballistic stability is provided by the rear fins, which also house the two interconnected laser transceiver guidance units. The latter act as the relays between the aiming unit and the missile's forward-positioned electronics and control section.

Each of the transceiver units incorporates a laser receiver, a signal processor and a transmitter in a small cylindrical pod. The reasons for two electrically interconnected pods being fitted are system redundancy and the prevention of any possible screening effects acting upon the guidance signals.

The transmitter is mounted in the nose of the pod and relays the command uplink data to the missile's forward-mounted electronics. The optical data signals are detected by small pop-up antennas connected to the control unit which, apart from software changes, is essentially unchanged from that used on the Javelin.

The missile canister is a sealed lightweight environmental container which acts as a recoilless launcher tube and is discarded after use. It houses an electrical interface connector to pass firing signals from the aiming unit to the missile. At launch the front cap of the canister is blown off by the gas pressure when the missile gyro is fired.

The reusable Aiming Unit consists of a guidance head and a control unit. The former, which requires no alignment procedure, has an optical stabilisation system, a guidance transmitter, an aiming mark injector and a  $\times 6$  magnification monocular sight — all housed in an environmentally sealed light alloy casting.

The control unit consists of a lightweight moulded case with an environmentally sealed compartment (containing the wind offset switch and electronic assemblies for processing and control), an externally mounted battery box and an attached control handle assembly. The control handle contains the joystick, trigger, system on/off switch, fuze selection switch and superelevation button.

In combat when the gunner receives a target indication he acquires it in the monocular sight and selects 'system on'. He then tracks the target by moving the weapon system so that coincidence is maintained with the aiming mark. This action automatically generates lead angles, in both azimuth and elevation. The gunner then operates the trigger mechanism.

The missile is launched from the canister by the first stage motor and, at a safe distance from the gunner, is boosted to supersonic velocity by the second stage rocket motor. The gunner continues to track the target by keeping the aiming mark superimposed over it by use of the thumb-operated joystick. The missile guidance system lock-on is automatically maintained on the centre of the aiming ring. On reaching the target the missile's warhead is detonated either by impact or the proximity fuze circuit. If after launch it is realised that the target is in fact a friendly aircraft then the gunner has the facility to command the missile to self-destruct.

A Trainer Set, suitable for both initial and continuation training, is also available for both the shoulder-launched and LML Starburst applications.

### Variants

#### Starburst Lightweight Multiple Launcher

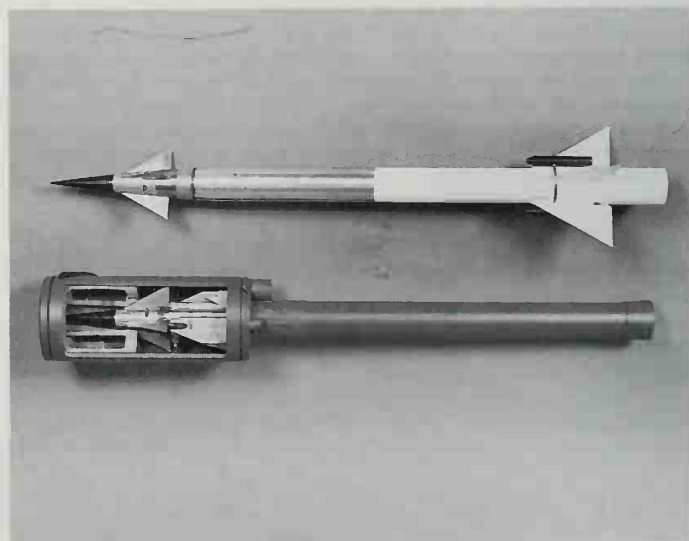
The Starburst LML is similar to the LML described in the Javelin entry except that it uses three standard Starburst canistered missiles and a standard Starburst Aiming Unit as the clip-on equipment.



Shorts Starburst Close Air Defence Missile System in shoulder launch mode



Shorts Starburst Close Air Defence Missile System being fired from the top of a Spartan APC in the shoulder launch mode



Shorts Starburst Close Air Defence Missile System showing the Starburst missile (top) and cutaway missile canister with Starburst missile in its ready-to-launch position (bottom)



### Starburst Lightweight Multiple Launcher (Vehicle)

The Starburst LML(V) is similar to the turret ring-mounted strengthened head LML(V) described in the Javelin entry except that it uses three standard Starburst canistered missiles and a standard Starburst Aiming Unit as the clip-on equipment.

### Starburst Lightweight Multiple Launcher (Naval)

The Starburst LML(N) has been developed for naval use.

### Starburst Naval Multiple Launcher

The Starburst Naval Multiple Launcher (NML) consists of a lightweight tubular turret supporting power-assisted azimuth and elevation drives for two missile panniers, each containing four ready to fire Starburst missiles.



Shorts Starburst Close Air Defence Missile System Aiming Unit

The elevation arm supports the guidance and fire control unit, incorporating a thermal imaging acquisition and tracking sensor for 24 hour operation. Cueing is by the ship's target acquisition systems or the weapon operator.

### Self-Propelled Starburst

A power-operated eight-round launcher system with collocated Air Defence Alerting Device (ADAD), power-operated panoramic sight with integral thermal imaging for night operation, control console (with built-in test facility) and a power distribution system has been developed. A full description of the system is given in the *Self-Propelled Surface-to-Air Missiles* section.

### Starburst Upgrades

Since Starburst's service introduction Shorts has been working on a number of system upgrades. These include:

- (a) the substitution of a Thomson-CSF radar proximity fuze to increase the proximity fuzing distance by around 400 per cent over the current system so as to enable greater effectiveness to be made of the pre-fragmented blast warhead's lethal radius. The fuzing modification is being tested during 1991 and is planned to be available from the beginning of 1992
- (b) the introduction of a non-rechargeable Crompton Vidor lithium sulphur dioxide battery pack as an alternative to the current three rechargeable Ni/Cd batteries to obviate the need to carry many spare batteries and a recharging unit.
- (c) the introduction of a clip-on night sight unit. Successful trials have taken place with a 1.4 kg sight based on a Simrad KN200 image intensifier.

### SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	1.394 m
DIAMETER	0.197 m
WEIGHTS	
aiming unit	8.5 kg
missile in canister	15.2 kg
PROPULSION	two-stage solid propellant
GUIDANCE	beam riding laser
WARHEAD TYPE	2.74 kg HE fragmentation with contact and proximity fuzing
MAX SPEED	Mach 1 plus
MAX EFFECTIVE RANGE	well in excess of 4000 m
LAUNCHER	manportable single round with grip-stock, three-round Lightweight Multiple Launcher

**Status:** Production. In service with the United Kingdom (Army).

**Manufacturer:** Short Brothers PLC, Defence Systems Division, Montgomery Road, Belfast BT6 9HN, Northern Ireland.

Telephone: (0232) 458444

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## Shorts Javelin Low Altitude Surface-to-air Missile System

### Development

The Shorts Javelin close-range air defence weapon was developed under contract to the British MoD from 1979 as a follow-on to the Shorts Blowpipe system and was first revealed in September 1983 by which time initial firing trials had already been completed.

The Javelin has been designed to counter a wide range of low level air defence targets and it employs semi-automatic command to line-of-sight (SACLOS) guidance, rather than infra-red detection, to engage its target. Its range enables it to engage and destroy high speed attacking aircraft before they are able to release their weapon load. The Javelin can also be used against helicopters and has a secondary surface-to-surface capability.

In comparison with the earlier Blowpipe, the Javelin has a new warhead, a more powerful second stage motor for increased range and it has also benefited from recent advances in video microprocessing techniques. The updated guidance system, which has been incorporated in a new aiming unit, makes the operator's task much easier. The aiming unit of Javelin has been designed so that it is compatible with the current Blowpipe system.

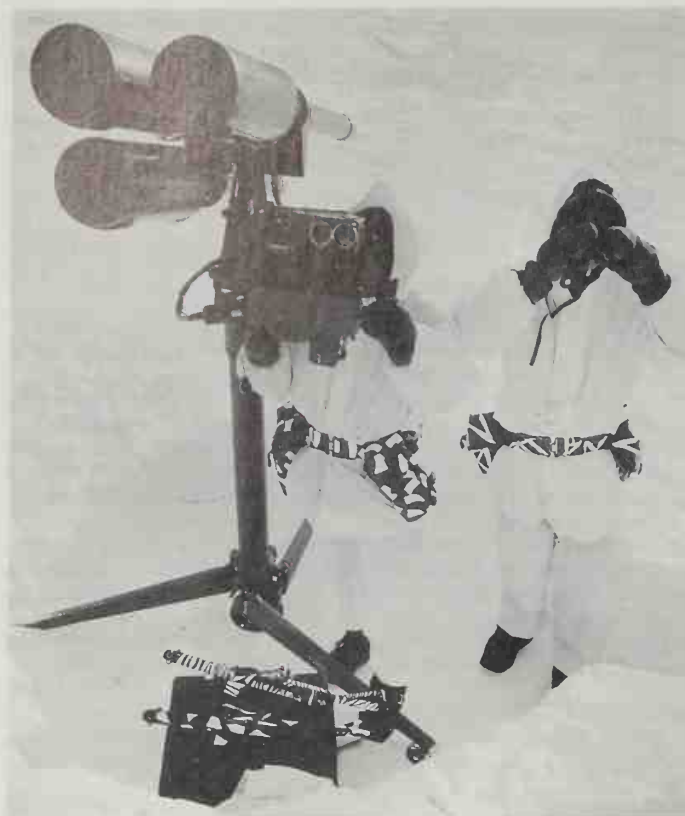
Shorts stress that the Javelin does not rely on the target's infra-red signature and is therefore almost impossible to counter by decoys such as hot flares. Compared with the earlier Blowpipe, training time is much reduced with the Javelin system. First production Javelins were completed in 1984 and they have replaced Blowpipe on a one-for-one basis in regular units in the British Army and Royal Marines (the latter having one troop of

three sections known as 3 Commando Brigade Air Defence Troop). During wartime in the British Army, the Javelins will normally be used in the forward area of operations under the control of brigade or higher level operations. Its three main roles are vital point (VP) defence where it is ideally sited about 500 m from the VP area, as a gap filler for the Rapier systems and for route defence where about 12 teams are required to cover a 12 km distance. The latter is the most rarely used mode of Javelin deployment.

For the rear areas four TAVR Blowpipe Regiments will be deployed and their observation posts sited well in front of their team positions in order to give as much warning as possible to the manual acquisition weapons. As both Javelin and Blowpipe are relatively slow when compared to the Rapier systems they are not suited to engaging high speed crossing targets but can be placed to engage approaching targets in a 30 to 40° arc. Normally they are engaged head-on at a range of approximately 7000 m with target interception occurring at some 3000 m after a 14 second flight time. The four TAVR Regiments have been converted to Javelin.

In June 1984 Shorts announced a second order worth £35 million from the British MoD for production of Javelin. This increased home and exports sales to £120 million. In the middle of the same year it was announced that the Javelin had been selected by the Royal Navy to provide special protection against Kamikaze-type attacks on naval vessels, especially those operating in the Middle East. In January 1985 Shorts announced that it had received a third production contract valued at £25 million for the Javelin which brought the total Javelin order book up to over £160 million.

According to Shorts, effectiveness of the Javelin close range SAM has been demonstrated in British Army practice camps where so many Shorts



*Shorts Lightweight Multiple Launcher (LML) in service with the British Royal Marines*

Skeet targets were destroyed that one camp, at least, had to be put back due to lack of targets. One aimer of 10 (Assaye) Air Defence Battery had a 100 per cent success rate in 1985 when he destroyed eight Skeet targets in eight engagements.

During the 1986 British Army Equipment Exhibition, Shorts revealed that it was acting as Project Manager for all aspects of Close-Air Defence Weapon Systems (CADWS) on behalf of the MoD. This not only includes Blowpipe, Javelin and Starstreak, but also the system integration for enhancements to UK CADWS, the THORN EMI Air Defence Alerting Device (ADAD), the IFF equipment, the thermal imaging night sight and the Air Defence Command and Information System (ADCIS).

#### Description

The Javelin SAM system consists of two main components; the missile sealed within its launching canister and the aiming unit, and lightweight carrying cases are provided for both.

The canister in which the missile is factory-sealed is a lightweight environmental container designed to act as a recoilless launcher. It houses the guidance aerial, the electrical connections and the thermal battery to power the aiming unit after the missile launch.

The front cap is blown off by gas pressure when the missile gyro is fired and the laminated rear closure is ejected at launch.

The missile is a 1.4 m long slender tube with the fuzes in the tip and the warhead in the centre. The guidance equipment is in the forward part of the body and the rocket motors are in the rear. There are four delta-shaped aerofoils in the nose for aerodynamic control and four at the tail for ballistic stability. A self-destruct facility is incorporated. The nose section is free to rotate independently of the main body, to which it is attached by a low friction bearing. Twist and steer commands to the control fins guide the missile with a high response rate.

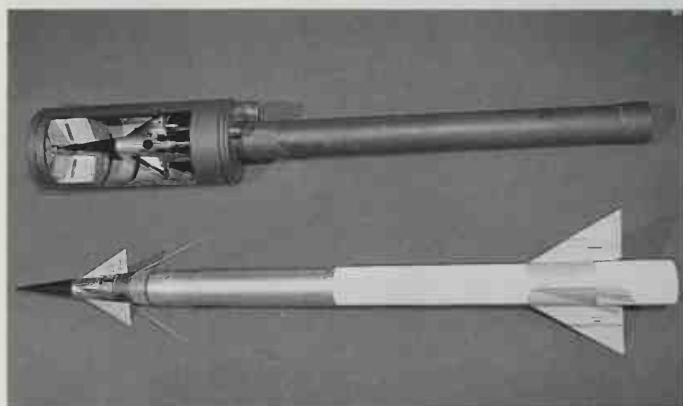
The aiming unit is a self-contained firing and control pack with a pistol grip firing handle on the right side. It contains a stabilised sighting system which provides manual target tracking and automatic missile guidance through a solid-state TV camera.

Digital commands from the camera are fed to a microprocessor and the resultant guidance demands are transmitted to the missile by radio. The simple controls on the handle include the firing trigger, thumb-controlled joystick and system, fuze mode and superelevation switches. Other controls include channel selector switches for the transmitter and an automatic cross-wind correction switch.

Marconi Avionics were awarded their first production contract, worth over £5 million, for their advanced television guidance system used in the Javelin in May 1984. The automatic gather and guidance system comprises a miniature solid-state CCD (charge-couple-device), television camera and zoom lens, sophisticated signal processing electronics and a two-axis



*Standard manportable Shorts Javelin SAM system deployed*



*Shorts Javelin missile out of its launcher tube (bottom) with missile in its launcher tube (top)*

sub-miniature gyro assembly. The camera unit and associated data extraction equipment is produced by the company's Electro-Optical Products Division, Basildon and the gyro assembly by the Gyro Division, Rochester. The complete electro-optical and gyro subsystem are contained within the operator's lightweight aiming unit. This was made possible by the use of a CCD imaging array (a light sensitive microchip) to form the TV picture, and by high-density electronic packaging involving multi-layer hybrid micro-circuits.

The Javelin is made ready for action by clipping the aiming unit onto the canister which takes less than five seconds.

Information of an imminent attack can be received over the radio net or by the team scanning the horizon visually. The aimer acquires the target in the monocular sight and switches on the system, selecting the frequency of the guidance transmitter and the mode of the fuze (proximity or impact). This activates the tracking electronics and projects an illuminated stabilised aiming mark (a red circular reticule) into his field-of-view. The target is tracked briefly with the aiming mark to establish a lead angle, the safety catch is released and the trigger pressed. Range is indicated stadiametrically in the aimer's eyepiece which has a magnification of  $\times 6$  compared with  $\times 5$  of a Blowpipe.

The firing trigger activates two thermal batteries, one of which supplies the power to the aiming unit while the other supplies power to the missile.

The gyro of the missile is run up by the action of the cordite burning charge, initiated by the thermal battery. The gas overpressure blows off the canister sealing cover and the missile is boosted from the canister by the first stage motor (the same type as used in the Blowpipe) which burns out in 0.2 seconds before the missile emerges from the tube. Then, at a safe distance from the aimer, the weapon is accelerated to its supersonic burn-out speed, by the second stage sustainer motor.

The Javelin's wing assembly comprises four wings mounted on a central tube and is housed at the forward end of the canister until the round is launched. The wingtips are folded in this stowed position to reduce the diameter of the canister. While the missile is being launched the main body of the missile passes through the wing assembly which is arrested by a



band of tape around the rear body. When the missile is clear of the launch canister its wingtips are unfolded by the roll action that the booster motor applies to the rear body. A slight cant on the wings then rolls the missile continuously throughout flight in order to maintain aerodynamic stability. The missile is not armed until it is at a safe distance from the aimer and if guidance signals are lost it self-destructs. Javelin retains the twist and steer control method of Blowpipe with the control surfaces being mounted on the nose section which is free to rotate.

The camera detects the missile flares and, using digital techniques transmits guidance demands to the missile. The TV guidance datum line is collimated with the aiming mark which is maintained on target by the gunner using the thumb joystick. In the event of sight failure, the integral TV camera system tracks the missile flares and sends an error signal via the command link to adjust its flight trajectory as needed.

The warhead is detonated either by the preset impact or proximity fuze.

#### Variants

### Lightweight Multiple Launcher

The Lightweight Multiple Launcher (LML) has been developed by Shorts to provide the Javelin with a multi-engagement capability. All LML systems use three standard Javelin canistered missiles and a standard shoulder-launched aiming unit as clip-on equipment.

In the free-standing application, the support tube is held vertically by the tripod legs which pivot off an eccentric support collar. Screw jacks positioned between the top of the sleeve and the legs, are used to level the launcher.

When deployed in a trench the support collar can be slid partially down the support tube where it is clamped at the appropriate height. This means one leg hangs vertically while the other legs are used to provide lateral support to the launcher.

To deploy the LML the tripod stand is erected by unfolding the legs and sliding the leg support collar to the bottom of the support tube which is then locked in position. The LML head is then lifted onto a spigot on top of the tripod stand and the sight arm is released from its stowed position and unfolded into its operational state. After fitting the aiming unit onto the sight arm saddle and loading the three missiles in position, the LML is ready for action and the aimer now follows normal Javelin operational procedures. The LML is in production and in service with UK and overseas forces.

### Lightweight Multiple Launcher (Vehicle)

The LML(V) is suitable for mounting on many types of armoured personnel carriers and has been mounted on the Shorts Shorland S53 (4 x 4) Air Defence Vehicle variant of the Shorland S52 Armoured Patrol Car.

The turret ring is fitted over a hatch opening and is provided with its own integral hatch cover. The ring carries a pintle for mounting the vehicle variant of the traverse head. Turret traverse relative to the turret ring is  $\pm 40^\circ$ . Six missiles in their launch-containers are stowed in racks either side at the rear of the S53 vehicle.

The ring is provided with a handgrip and frictional brake so enabling the aimer to slew it to approximate target bearing and then track the target. The LML(V) is in production and in service overseas.

### Lightweight Multiple Launcher (Naval)

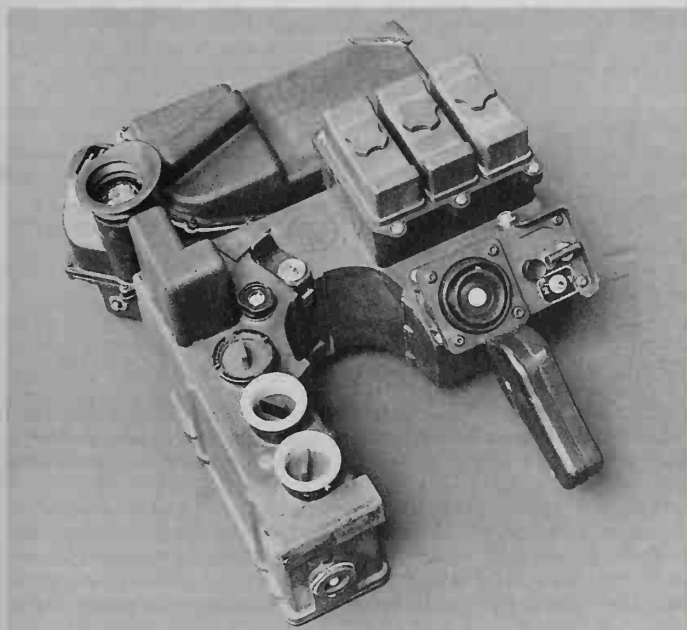
The LML(N) has been developed for naval applications.

#### SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	1.39 m
DIAMETER	0.076 m
WING SPAN	0.275 m
WEIGHTS	
aiming unit	8.9 kg
missile	12.7 kg
missile in canister	15.4 kg
missile in field-handling container	19 kg
missile in field-shipping container	43.0 kg
PROPULSION	two-stage solid propellant
GUIDANCE	semi-automatic command to line-of-sight (SACLOS)
FOV	
monocular	180 mils
magnification	x6
TV FOV	
wide	230 x 180 mils
narrow	36 x 36 mils
WARHEAD TYPE	2.74 kg HE fragmentation with contact and proximity fuzing
HE CONTENT OF WARHEAD	0.6 kg
MAX SPEED	about Mach 1



Manportable Shorts Javelin SAM being launched



Close up of the Javelin aiming unit



Shorts Javelin SAM LML(V) installed on a Shorts Shorland S53 air defence vehicle

MAX EFFECTIVE RANGE	about 5500 m (against helicopters)
MIN EFFECTIVE RANGE	about 4500 m (against jet aircraft)
MAX EFFECTIVE ALTITUDE	about 300 m
MIN EFFECTIVE ALTITUDE	3000 m
POWER SUPPLY	27.5-35.5 V DC supplied by canister thermal battery and three 12 V rechargeable batteries in aiming unit
LAUNCHER	manportable single round with grip-stock

**Status:** In production. In service with seven countries (a total of 11 services) including United Kingdom (Army, TA and Marines), Canada, Dubai, Jordan (may have ordered system in 1988), South Korea (\$30 million contract placed in December 1986 with first deliveries made in April 1987, further orders involving possible local assembly of system have been negotiated), Oman and Botswana. By 1991 over 16 000 Javelin SAMs had been completed.

**Manufacturer:** Short Brothers PLC, Defence Systems Division, Montgomery Road, Belfast BT6 9HN, Northern Ireland.  
Telephone: (0232) 458444  
Telex: 747087  
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## Shorts Blowpipe Low Altitude Surface-to-air Missile System

### Development

In the early 1960s Shorts started the private venture development of a manportable SAM system, subsequently called Blowpipe, that could provide defence against aircraft in the forward battlefield area.

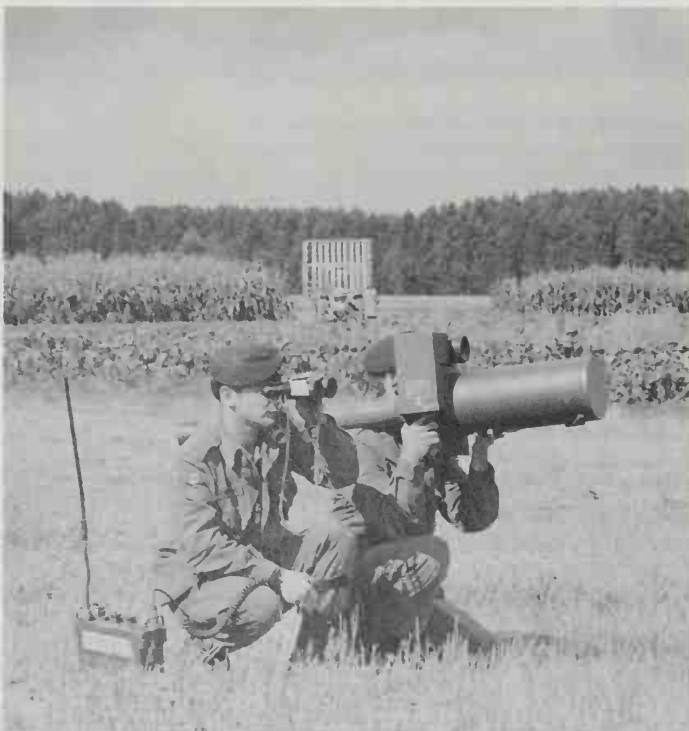
By 1965 the first trial missiles had been successfully fired and the missile system was officially revealed in September 1966 at the Farnborough Air Show.

In 1968 the British MoD started to provide funding for Blowpipe with first manned firings taking place in late 1968. By early 1972 the system had completed its research and development phases and had been accepted for final evaluation with the British Army. They placed an initial production contract for Blowpipe in 1972 and Canada was the first export customer the following year. First production Blowpipe systems were completed in 1974 and entered service with the British Army in 1975 when the first troop was formed at Kirton-in-Lindsey.

A normal British Army Blowpipe detachment consists of three men. In the UK a Land Rover (4 × 4) light vehicle is used and this also carries a small number of reserve missiles whereas the BAOR use an Alvis Spartan APC which carries a total of 10 missiles. One man normally stays with the vehicle ready to bring new missiles forward while the other two provide the firing unit.

Following its issue to British Army units in the UK and then BAOR, Blowpipe was issued to the Territorial Army where it replaced the famous Bofors 40 mm L/70 towed anti-aircraft guns.

Blowpipe was first received in 1978 by the 103 Air Defence Regiment, Royal Artillery (The Lancashire Artillery Volunteers) followed by 102 Air Defence Regiment, Royal Artillery (Ulster and Scottish) and 104 Air Defence Regiment, Royal Artillery, all part of 23 Artillery group which will deploy to BAOR in time of war. Each regiment has three batteries.



Two-man Blowpipe team of Canadian Armed Forces deployed in field (Canadian Armed Forces)

Although Blowpipe requires more training than the US Redeye — in that it uses line-of-sight guidance rather than infra-red detection to engage its target, and was designed specifically to counter oncoming attacks from high speed aircraft by destroying the target before it can release its weapon load — Shorts believes it is more effective than Redeye or the Soviet SA-7.

Although its primary role is to engage aircraft and helicopters, Blowpipe has a secondary role against surface targets out to a range in excess of 3000 m.

In mid-1981 the Canadian Department of Supply and Services placed its second contract for the Blowpipe system by which time the system had been adopted by eight armed forces and six countries (including Canada and the UK).

Blowpipe was used by the Argentinian and British armed forces in the 1982 Falklands campaign, with the former shooting down one British BAe GR Mk 3 Harrier.

In the Spring of 1986, quantities of Blowpipes found their way to both the Afghanistan Mojahedin and the Nicaraguan Contra guerrillas.

Some sources have indicated that a number of the guerrilla weapons have been diverted to the Pakistani Army as a kind of tax. Mojahedin Blowpipes have also been used in the ATGM role, and have destroyed several BTR-series APCs.

As early as June 1979, Shorts had announced preliminary details of an advanced guidance system for Blowpipe which by then was already undergoing trials with excellent results. A multi-million pound MoD contract for further development was awarded in June 1980. This was originally known as the Blowpipe Mk 2 but eventually entered production as the Javelin system (qv). Blowpipe missiles can be used with the Javelin aiming unit if required.

In mid-1982 the Government of Thailand placed its third order for the Blowpipe missile for use by the Royal Thai Air Force for airfield defence.

Late in 1982 the MoD of the Sultanate of Oman placed a multi-million pound order with Shorts for Blowpipe missiles and support equipment. In the British Army, Blowpipes were manned by the Royal Artillery and organised into batteries with each battery having two troops each of three sections with each section having four Blowpipes.

BAOR had four Blowpipe batteries (10, 21, 43 and 111) but these have now been converted to Javelin, with each battery being allocated to a division in time of war and tasked at brigade level.

By mid-1983, the Shorts Blowpipe order book, for both home and export markets, stood at over £200 million and by 1989 over 19 000 Blowpipe and 16 000 Javelin missiles had been produced. Although Javelin has now replaced Blowpipe in front line British Army and Royal Marine units, it continues in limited and reducing production for the export market.

### Description

The Blowpipe system consists of two main components; the missile sealed within its launching canister and the aiming unit, with lightweight carrying cases being provided for both.

The Blowpipe missile itself is a slender tube 1.4 m long with the warhead in the centre section and the fuzes in the tip of the nose. The forward part of the body contains the guidance equipment and the rocket motors are to the rear.

The short 0.2 second burning time of the booster stage was achieved by using thin sections of high burn rate pressurised propellant. Roll is induced in the missile by suitably angling some of the small nozzles drilled through the rear end plate.

The second stage Crake sustainer uses a conventional double base propellant to minimise smoke emission and exhausts its gases by ducting through the centre of the first spent stage booster motor via a lined blast pipe.

Premature ignition of the second stage as a result of an inadvertent ingress of hot gas from the first stage operation is prevented by a specially designed closure for the second stage nozzle. There are four delta-shaped aerofoils in the nose for aerodynamic control and four at the tail to provide ballistic stability. In each case the aerofoils are of supersonic double-wedge profile.

When a period of five seconds passes without any guidance signals being received, an in-built self-destruct facility is operated. This is initiated





*Blowpipe missile leaving launcher during trials*

either by the gunner cutting off transmission or, if the missile goes off course, while in flight.

An unusual feature of the Blowpipe missile is that the nose section is free to rotate independently of the main body, to which it is attached by a low-friction bearing. Twist and steer commands to the control fins guide the missile, resulting in a fast response rate. The container in which the missile is factory sealed is a lightweight environmental canister designed to act as a recoilless launcher and houses the firing sequence unit, the thermal battery to power the aiming unit and the guidance aeriels and electrical connections.

The aiming unit is a self-contained firing and control pack with a pistol grip at the right side and contains a radio transmitter, an auto-gathering device, a monocular sight and optional IFF interrogator system. The simple controls include a trigger, thumb-controlled joystick and switches for fuze option, auto-gather, and guidance command frequency change. Information that an attack is imminent is either received over the radio net or by the team scanning the horizon visually.

The Blowpipe is made ready for action in less than five seconds by clipping the aiming unit onto the canister. The gunner then grasps the front of the canister with his left hand and clasps the hand grip on the aiming unit with his right hand and supports the remainder of the launcher on his right shoulder.

He acquires the target in his monocular sight which has a magnification of  $\times 5$  and is graticulated to assist in range estimation and to allow for crosswinds. He then switches on the system, selects the frequency of the guidance transmitter unit and the mode of the fuze (proximity or impact).

In addition to the monocular visual sight, the aiming unit is also fitted with a sensor which detects the position of the missile in relation to the line of sight. The Blowpipe missile is fitted with flares which provide outputs for both visual and automatic IR tracking. The error signals generated in the sensor are sent to the missile via a radio transmitter in the aiming unit and an aerial in the canister.

A receiver in the missile then passes these signals to the control unit and this automatically brings the weapons into the line of sight to the target. The effective range of the missile is limited by the available speed and lateral acceleration after the burnout of the second stage motor. The automatic system is intended for use when gathering the missile. It can do this much more quickly and consistently than the aimer and this enables targets to be intercepted at close range. For longer range targets, automatic guidance will cease after two or three seconds and after that the missile is under the control of the aimer's thumb.

To fire, the gunner releases the safety catch and squeezes the trigger to activate a generator which supplies current to thermal batteries in both the canister and the missile. The battery which powers the aiming unit is fitted in the canister. The gyro of the missile is run up by the action of the cordite burning charge, initiated by the thermal battery. The gas overpressure blows off the canister sealing cover. The missile is launched by the booster motor (which is also used in the Javelin missile), which burns out before the weapon emerges from the tube and, at a safe distance from the aimer, the missile is accelerated to supersonic speed by its sustainer motor.

After burnout, it cruises as a fully controlled dart and is automatically gathered into the centre view field of the aimer who then guides it onto the target using the thumb-controlled joystick.

The aimer keeps the missile coincident with the target until interception. When the missile is being guided by thumb control it is not necessary to track the target accurately. The aimer only needs to keep it in the field-of-view of the monocular.

There may be times when the automatic gathering system cannot be used and in such circumstances the aimer can switch out the automatic gathering system before missile launch and use the thumb control throughout the engagement.

The warhead of the Blowpipe is detonated either by impact or proximity fuze. The warhead is a dual blast shaped charge type and is capable of penetrating the armour plate of light armoured vehicles. Once the target has been destroyed the aiming unit is separated from the empty canister and another loaded canister attached. In peace time the empty canister can be returned for reloading and reuse.

## Variants

### Thai Blowpipe LCMADS

The Royal Thai Air Force has developed and deployed its own vehicle and ground pedestal-mounted twin-Blowpipe launcher version of the LCMADS system with an attached optical sighting unit.

## SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH OF CANISTER	1.40 m
LENGTH OF MISSILE	1.35 m
DIAMETER OF MISSILE	0.076 m
WING SPAN	0.275 m
WEIGHTS	
missile and canister	14.5 kg
missile	11 kg
aiming unit	6.2 kg
PROPULSION	dual-base solid propellant booster and sustainer rocket motors
GUIDANCE	IR auto-gathering, then command to line-of-sight (CLOS)
WARHEAD	2.2 kg HE dual fragmentation shaped charge with impact and proximity fuzing
MAX SPEED	about Mach 1
MAX EFFECTIVE RANGE	about 3500 m
MIN EFFECTIVE RANGE	about 700 m
MAX EFFECTIVE ALTITUDE	2500 m
MIN EFFECTIVE ALTITUDE	10 m
LAUNCHER	manportable single round with grip-stock

**Status:** In limited production. In service with Afghanistan (Mojahedin guerrillas); Argentina (Army, Special Forces and Marine Corps); Canada (Armed Forces); Chile (Air Force and Marines); Ecuador (Army); Malawi (Army); Nicaragua (Contra guerrillas); Nigeria (Army); Oman (Army); Pakistan (Army — from Afghanistan guerrillas); Portugal (Army); Qatar (Army); Thailand (Air Force); United Kingdom (British Territorial Army units).

**Manufacturer:** Short Brothers PLC, Defence Systems Division, Montgomery Road, Belfast BT6 9HN, Northern Ireland.  
Telephone: (0232) 458444  
Telex: 747087  
Fax: (0232) 705293

## UNITED STATES OF AMERICA

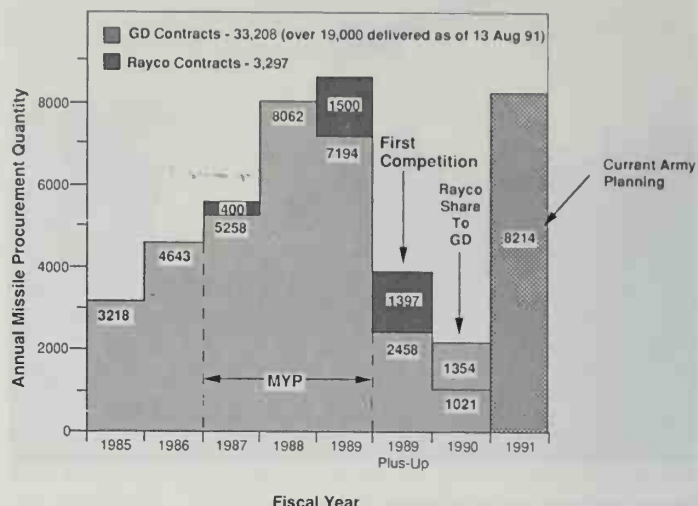
## General Dynamics FIM-92 Stinger Low Altitude Surface-to-air Missile System

## Development

Even as the General Dynamics FIM-43A Redeye system achieved its initial operational capability in 1967, a joint work programme between the US Army and the General Dynamics Pomona Division was in the second year of studying new design concepts and initiating the testing of components for a Redeye II weapon system with an all-aspects target engagement capability. This Advanced Seeker Development Programme (ASDP) eventually gave rise in 1972 to the second-generation manportable XFIM-92A Stinger design with a more sensitive seeker head and a better kinematic performance when compared to its predecessor and with the addition of a forward-aspect engagement capability to its flight envelope and an integral IFF system.

However, the first guided tests in 1974 at the White Sands Missile Range resulted in a number of problems being found with Stinger which caused the US Army Missile Command (MICOM) to request that the Ford Aerospace Aeronutronic Division develop what was designated the Stinger Alternate system, using a reusable laser beam device attached to the launcher assembly as the guidance system. To cure problems found with the system and to reduce the continually rising costs, General Dynamics initiated a design review which resulted in a 15 per cent reduction in the total number of electronic parts used and the introduction of a separate grip-stock assembly. These changes made a considerable improvement in the test results obtained in the 1975 firings, and by February 1976 the US Department of Defense was satisfied that the early guidance difficulties had been overcome. They were so convinced that in 1977 the funding used for the development of the Stinger Alternate was stopped. In 1978, following an Engineering Development Programme which had needed only 130 test round firings to validate the design, Stinger was finally released for production. This started in 1979 with the first production systems being delivered the same year and the first military units achieving initial operational capability status in February 1981 with the basic FIM-92A Stinger version.

In mid-1977 after a four-year advanced development programme, and just before the basic Stinger was released for production, General Dynamics

Total Procurement Quantities  
Stinger-RMP Missile

was awarded a Full Scale Engineering Development contract for the next generation of Stinger. This involved the fitting of a microprocessor-controlled Passive Optical Seeker Technique (POST) homing head which uses a dual infra-red (IR) and ultra-violet (UV) rosette-pattern image scanning guidance technique to enhance the missile's target detection capabilities. The use of the different seeker only involves a modular change to the weapon and allows it to discriminate effectively between a target, any deployed IR decoy flares and background clutter when they lie within detectable range thus preventing a false launch.

Limited procurement of this FIM-92B Stinger-POST version began in 1983 alongside the earlier variant with the production of both ending in 1987. Operational deployment of Stinger-POST systems to the US Army began in July 1987. A total of 15 669 Basic Stinger and just under 600 Stinger-POST missiles were produced.

As a further increase to the effectiveness of Stinger, General Dynamics began development in FY85 of what is essentially a fourth-generation manportable SAM system. Known as the Stinger-Reprogrammable MicroProcessor (RMP) system, the change allows the onboard digital microprocessor to be periodically updated with new software to counter any new threat technology instead of having to go through a missile redesign each time. Production of this FIM-92C model began in November 1987 at the General Dynamic's Valley Systems Division Stinger plant in California. The export version of the Stinger-RMP does not have the software module. In early 1988 Valley Systems Division was awarded a \$695 million multi-year Stinger production contract to produce over 20 000 rounds through 1991. A final total of over 40 000 Stinger-RMP missiles is expected.

Prior to General Dynamic's production of the Stinger-RMP, on 2 September 1987 the US Army MICOM selected Raytheon Missile Systems Division as the second source contractor for production of this version. The initial \$24.6 million contract was for 400 Stingers with a \$54.4 million option for an additional 1500 missiles which was exercised in 1989. Raytheon was allowed to compete with General Dynamics from 1990 onwards for the annual production contracts. This is being done in order to keep the overall acquisition costs down for the US armed services. Raytheon was declared 'qualified' for bidding purposes for the FY91 contract bid.

In 1983 a six nation NATO consortium headed by Germany agreed in principle with General Dynamics to co-produce Stinger-RMP export variant systems. The other five signatories were Belgium, Italy, the Netherlands, Greece and Turkey. The prime Stinger Project Group European contractor is Dornier GmbH, with a total German production requirement of some 4500 systems, while the final Turkish requirement is believed to be 4800 systems. Low-rate production is due to start in 1992 although Germany, the Netherlands and Turkey have already taken delivery of small batches directly from the manufacturer. The Netherlands is expecting to buy 1709 missiles (90 for the Navy/Marine Corps, 944 for the Army and 675 for the Air Force). Since signing the agreement, both Belgium and Italy have cancelled their participation in the production programme although the latter bought 150 launcher grips and 600 FIM-92A Stingers from the manufacturer to fulfil its immediate training requirements.

The European companies which have been assigned Stinger component co-production contracts by Dornier GmbH include Fokker Special Products (a Dutch company given an order for 12 500 control assemblies to be delivered from the first half of 1991 - its subsidiary company ELMO will supply part of the electronics for the order), Aselsan (Turkey), Rocketsan (Turkey, which will supply the booster/sustainer propulsion units and solid



German soldier using Stinger manportable SAM in field





*Stinger manportable SAM with missile just leaving launcher*

fuel propellant), Kalekalip (Turkey), Coskunoz (Turkey) and Barmek Holding (Turkey). There are some 20 German, Dutch, Greek and Turkish companies involved in the programme.

The production run will total 12 650 Stinger-RMP export variant systems by 1998. The various components and fuel made in the four countries will be assembled at the Dornier facilities in Friedrichshafen and Nuremberg. According to the MoU signed the European Group cannot export to other NATO countries without US permission and requires specific permission to sell to non-NATO members. However, despite this future co-operation with Switzerland, which has its own MoU to produce 50 per cent of its Stinger requirement in joint manufacture with the US makers, cannot be ruled out.

In German service it is known as the Fliegerfaust-2 (FIF-2) and is being deployed with the army, navy and air force. A new palletised launch platform is being developed by Dornier for use on ships, wheeled and tracked vehicles. In the case of the air force the palletised launcher will be deployed on light (4 x 4) Unimog 1300L trucks with towed twin 20 mm Rh-202 cannon for airfield and Vital Point (VP) defence whereas the army will use it on tracked vehicles for battlefield air defence. All three services will also use the manportable version.

Both Germany and the Netherlands have also undergone trials on their manportable Stinger systems with an early warning radar system to enhance its performance. The Royal Netherlands Army used the Hollandse Signaalapparaten Radar Equipment Providing Omnidirectional Reporting of Targets at Extended Ranges (REPORTER) mobile trailer-mounted I/J-band radar system with an integral IFF system in a highly successful series of tests in late 1985. The radar provided early warning of targets up to 40 km away and flying between 15 and 4000 m altitude which were then handed over to a Stinger launch team for engagement.

Other nations which have ordered or been the recipient of varying numbers of Stinger systems include Bahrain, Chad, France, Iran, Israel, Japan, South Korea, Pakistan, Qatar, Saudi Arabia and the United Kingdom. Of these France and Chad have used limited numbers successfully against Libyan aircraft during the 1986-87 border skirmishes while the British Special Air Service (SAS) actually used a small number of FIM-92A Stingers during the 1982 Falklands conflict where they destroyed an Argentinian Air Force FMA IA 58A Pucara twin-propeller close-support aircraft during the 21 May San Carlos amphibious landings.

In September 1988 Switzerland chose the export variant of the Stinger-RMP for its manportable air defence system. A maximum of 2500 will be procured for a cost of \$315 million.

In mid-1986 the first shipments of an eventual 900-1000 FIM-92A model Stingers were sent to the Afghan Mojahedin guerrillas for use against Soviet and Afghan Air Force aircraft. The first combat use came on 26 September when Stingers destroyed three Mil Mi-24 Hind gunship helicopters during a battle near Jalalabad. As combat experience mounted, the presence of these weapons had by the end of 1987 resulted in considerable combat loss of fixed- and rotary-wing types and pressurised the Soviets into making a number of major modifications to their aircraft based there in order to reduce their vulnerability to IR guided missiles. The success with the Stingers continued throughout 1988 and into 1989 as the Soviets continued their withdrawal.

Aircraft types known to have been shot down by Stinger include MiG-17 'Frescoes', Sukhoi Su-7/17/20/22 series 'Fitters', MiG-21 'Fishbeds', MiG-23 'Floggers', Sukhoi Su-25 'Frogfoots', Antonov An-26 'Curls', Mil Mi-8/17 'Hips' and Mil Mi-24 'Hinds'. More importantly to the guerrillas they also forced the Soviets to adopt new and less accurate high level weapons delivery flight profiles thus considerably reducing the freedom of movement



*Stinger missiles shortly after launch with booster falling away as main motor accelerates missile towards target*

of the Soviet gunship and transport helicopters during operations in the hilly/mountainous areas. A 1990 US Army analysis of the Afghan Stinger operations concluded that of 340 missiles fired over the period covered by the report 269 has resulted in kills of fixed- and rotary-wing aircraft, giving a remarkable 79 per cent kill ratio. Of the kills 90 per cent were crossing targets and 10 per cent head-on targets.

The guerrillas have also introduced their own tactics for using Stingers. They used the weapon in an offensive manner by deploying a combat group armed with several launchers to the vicinity of an airfield and then for several hours interdicted the flightpath in order to try and destroy the larger logistic support and personnel transport aircraft which were needed to resupply the base.

Unfortunately, numbers of Stingers have been captured by the Soviets and the technology compromised.

Ironically it is the Stinger missiles delivered to Afghan guerrillas that have found their way to Iran where one was subsequently fired at the US Army Task Force 160 Hughes AH-6 special operations helicopters engaged in flights over the Gulf. Of the 20 launchers apparently captured by Iran only a few remain in its possession. Apart from the one used in combat another was recaptured by US forces aboard a badly damaged Iranian speedboat following an air-sea battle in the Gulf. Thirteen others were sold to Qatar in early 1988. Stinger systems were used in the region by the Royal Netherlands Marine Corps, the US Marine Corps, the US Navy and the Saudi Arabian armed forces for the close-range protection of surface-ships and shore installations.

A number of FIM-92A Stinger systems were also delivered to the Uniao Nacional para a Independencia Total de Angola (UNITA) movement in Angola during 1986-89 where they have been used successfully against the Soviet supplied Angolan Air Force destroying a number of jets and helicopters including one MiG-21, three Mil helicopters and a MiG-23 'Flogger C' (with a two-man Cuban crew that was captured) during the late 1987 battles in south-east Angola. In 1987 a small number of FIM-92A Stinger launchers were given to the Contra guerrillas fighting in Nicaragua against the Sandinista government. It is believed that these were committed to battle in the latter part of that year.

In US service all four armed services use the weapon and the US Air Force has small detachments trained to defend airfields and VPs, especially in the Far East at the four South Korean airbases used by its units. It has also been revealed that the American President's residences in Washington and elsewhere are protected by specialist Stinger teams in case of an aerial attack by terrorist organisations.

Each of the US Army's armoured, mechanised, light infantry, airborne and air assault Divisional Air Defense Artillery (ADA) Battalions have a Stinger Platoon (of four sections) with each of its four batteries. For the airborne and air assault divisions three of the sections have five two-man teams each while the fourth has only three teams to give a divisional total of four two-man section HQs and 72 firing teams. For the Division 86 mechanised and armoured units, the number of Stinger teams is reduced to 60 whereas the light infantry divisions only have 40. A team is normally equipped with a 4 x 4 Jeep or M998 series (4 x 4) HMMWV light vehicle, a GSQ-137 Target Alert Data Display (TADDS) comprising a 6 kg portable unit with a display, audio warning and VHF receiver, two AN/PPX-3 IFF interrogators and a basic load of six Stingers. The TADDS warns the team of an approaching aircraft, provides a tentative identification and gives approximate range and azimuth to the target. The data link between the



team and the radar can handle 49 friendly and 49 unknown (that is, hostile) targets. Each Army Chaparral, Vulcan, and Patriot and I-HAWK fire control platoon also carry one Stinger team set (less the TADDS) as part of their normal equipment allowance. During a heavy attack both team members would shoulder a launcher providing two independent ready-to-launch weapons with four extra weapons available.

The 82nd Airborne Division, air defence unit is the 3rd (Airborne) Battalion 4th ADA which is a combined Vulcan/Stinger unit equipped with the Tactical Defence Alerting Radar (TDAR). The Stinger teams use the M1025 Kevlar armoured variant of the HMMWV light vehicle which is suitable for air-portable/air-droppable assault missions. Each M1025 vehicle is equipped with two AN/GRC-160 FM radios (one of which has a TSEC/KY-57 cryptographic device) and a basic missile load of eight Stingers carried on two indigenously designed four-round racks that fit on the vehicle's rear bed.

Early warning is provided by the eight 1-15 km (on a 0.2 m<sup>2</sup> radar cross section target) range pulse Doppler D-band MPQ-49 Forward Area Alerting Radars (FAARs), with integral AN/TPX-50 (Mk XII) IFF systems held in the ADA headquarters radar platoon which transmit target position data to the TAADS by radio link. Increasingly, however, the FAARs are being used without TAADS and the Stinger teams are being cued onto a target by a voice communication VHF radio link direct to the radar operator. The FAARs are also used with the Chaparral and Vulcan air defence systems.

During Operation Urgent Fury – the US assault to remove the radical regime on the Caribbean island of Grenada – four Stinger teams and a headquarters element of the 3rd (Airborne) Battalion, 4th ADA 82nd Airborne Division accompanied the lead elements of the Division during the 25th October 1983 invasion. An additional 27 teams landed with the follow-on assault echelon.

In the US Marine Corps the Stinger system is assigned to the Low Altitude Air Defence (LAAD) battalions which have two firing batteries each of three platoons. A platoon has three sections each of five Stinger teams that are each equipped with an HMMWV light vehicle and four Stinger missiles.

A Marine Expeditionary Force (MEF) is assigned a fully automated Tactical Air Command centre, two Tactical Air Operations Centres, a Light Anti-Aircraft Missile (LAAM) battalion and a complete LAAD battalion (of 90 Stinger teams). A Marine Expeditionary Brigade (MEB) is assigned a Tactical Air Command Centre, a Tactical Air Operations Centre, a LAAM battalion and a LAAD battery (equating to four I-HAWK batteries and 45 Stinger teams) whilst a Marine Expeditionary Unit (MEU) has a single LAAD platoon (of 15 Stinger teams) attached.

In early 1988 the Marine Corps released a request for a proposal to the US defence industry for a manportable radar system to alert and cue Stinger missile gunners to the approach of hostile aircraft. Called the Lightweight Early Warning Detection Device (LEWDD) it must have portable subsystems with a total weight of less than 90.9 kg, a range of 20 km and be able to be set up in five minutes or less.

The US Navy uses Stinger teams to supplement warship and support vessel close-range air defences in high threat areas. A team of two is normally employed with the gunner located within a circular pedestal-type open mount. The other team member acts as a target locator using information sent over the vessel's internal communications net.

## Stinger Weapon Systems in Operations Desert Storm and Desert Shield

During the Gulf War Stinger systems were deployed extensively by a number of the Coalition forces but, as far as it is known, did not engage any Iraqi targets.

The latest version of the Stinger – Stinger-RMP equipped with the latest MOD IV software – was deployed with at least three of the four US Armed Services in support of the Gulf operations. Basic Stinger and export variant Stinger-RMP systems were also deployed with the armed forces of several of the other nations of the Coalition Forces.

Virtually every US Army ground combat unit had the Stinger either in the MANPADS role or as the principle armament of the wheeled Avenger PMS fire unit.

The US Marine Corps used the same two-man MANPADS team as the US Army, with the team (gunner and team chief) carried in a HMMWV with four ready-to-fire Stingers and two reload missile rounds.

The US Navy used MANPADS teams aboard its ships, primarily for close-in defence against small aircraft and very small surface craft. The US Army used the ATAS variant on its OH-58C helicopter in the air-to-air role whilst the US Air Force may have deployed some of its specially trained Air Police in the MANPADS role to guard some of the air bases it used in the Arabian Peninsular region.

### Description

A Stinger system comprises the launcher assembly with a missile, a grip-stock, an IFF interrogator and an argon gas Battery Coolant Unit (BCU) (which consists of the squib activated argon gas coolant unit and electrical generating chemical battery).

The launcher assembly consists of a glass fibre launch tube with frangible end covers, a sight, desiccant, coolant line, gyro-boresight coil and a

carrying sling. A detachable grip-stock which has a receptacle for the BCU is fitted with an IFF connector. The grip-stock is also fitted with an Impulse Generator (BCU energised), a seeker head uncage bar, a weapon launch trigger, an AN/PPX-1 IFF interrogator switch and a foldable antenna and control electronics for the missile gyro.

The missile itself is a two-stage solid propellant rocket motor type and in its FIM-92A version is fitted with a second generation cooled passive IR conical scan reticle seeker head with discrete electronic components to provide signal processing. They process the IR energy received from the target in the 4.1-4.4  $\mu$ m wavelength region to determine its relative angle and then, by using a proportional navigation guidance technique, continually predict an intercept point.

In the FIM-92B version the reticle seeker unit is replaced by one which uses an optical processing system. This has two detector materials, one sensitive to IR and the other responsive to UV energy, together with two microprocessors which are integrated into micro-electronic circuitry for the signal processing phase. The latest Stinger-RMP takes this one stage further by introducing a microprocessor reprogramming facility into the circuitry to allow for new threat characteristics and guidance tailoring.

In all cases the seeker output is sent as steering data to the guidance assembly which converts it into guidance signal format for the control electronics. This module then commands the two movable (of four) forward control surfaces to manoeuvre the weapon onto the required intercept course. The control concept used is known as the single channel rolling airframe type and, as such, considerably reduces both the missile weight and manufacturing costs. As the weapon nears its target the seeker head activates its Target Adaptive Guidance (TAG) circuit within one second of impact to modify its trajectory away from the exhaust plume towards the critical area of the IR target itself. The fuzing system allows for both contact activation as well as missile self-destruction after 20 seconds of flight time following the launch. The 3 kg Picatinny Arsenal warhead carried has a smooth fragmentation casing to ensure that the desired blast-fragmentation effect is achieved.

A typical tactical engagement follows this sequence of events. Once alerted to a target the gunner shoulders the system, inserts the BCU into its grip-stock receptacle and unfolds the IFF antenna. He then removes the front protective cover of the launcher tube to reveal the IR or IR/UV transparent frangible disc, raises the open sight assembly and connects his backpack IFF interrogator unit via a cable to the grip-stock. The gunner is now ready to visually acquire the target. He does this by using the sight and estimates its range with the estimation facility of the system. If required he now interrogates the target using the AN/PPX-1 system. This can be done by the gunner without having to activate the weapon. The azimuth coverage of the 10 km range IFF system is essentially the same as that of the optical sight enabling the gunner to associate responses with the particular aircraft he has in view. An audio signal 0.7 seconds after the IFF challenge switch is depressed provides the gunner with the cue as to whether the target is friendly or an unknown for possible engagement.

If he decides that it is unfriendly he continues to track the aircraft and activates the weapon system by depressing the impulse generator switch. This causes the impulse generator to energise the BCU which then releases its pressurised argon gas coolant to the IR detector and generates a dual polarity +20V DC output for at least 45 seconds to provide all the pre-launch electrical power required for the seeker coolant system, gyro spin-up, launcher acquisition electronics, guidance electronics, activation of the missile's onboard thermal battery and ignition of the ejector motor.

The seeker is allowed to look at the target through the IR or IR/UV transparent front launcher disc and when sufficient energy is received by the detector for acquisition to have occurred an audio signal is sent to the gunner. Total time required for tracking and missile activation is about six seconds. He then depresses the seeker uncage bar and, using the open sight, inserts the superelevation and lead data.

Once this is accomplished he depresses the firing trigger which activates the missile battery. This powers all the missile functions after launch and operates for around 19 seconds until the dual polarity +20V DC output drops below the required minimum for use. A brief time delay operates following which the umbilical-connector to the grip-stock is retracted and a pulse is sent to ignite the ejector motor. Total time to motor ignition from depression of the firing trigger is only 1.7 seconds. Upon ignition the initial thrust generated imparts roll to the missile airframe and starts the fuze timer system. The missile and its exhaust then breaks through the frangible discs at either end of the launcher tube.

Before the missile completely clears the end of the tube the ejector motor burns out in order to protect the gunner from the rocket blast and two movable control surfaces spring out. Once it clears the tube the two fixed and the four fixed and folded tail fins open out and the ejector motor is jettisoned. The missile then coasts to a predetermined safe distance from the gunner where the fuze timer ignites the combined boost/sustain rocket motor. When the correct acceleration rate is reached after one second of flight the Magnavox M934E6 fuzing circuit for the warhead is armed and the self-destruct timer started.

The seeker continues to track the target throughout the flight with the electronics processing the received signals to eliminate or reduce the line-of-sight pointing angle to the target. The weapon flies a proportional



navigation path to the interception point near to which the TAG-circuit is activated and a signal is generated within the seeker head to add bias to the steering signal causing the missile airframe to guide itself into a vulnerable part of the target. Even if the target is using 8 g manoeuvres the missile is still capable of engaging it.

Once the gunner has depressed his trigger and the missile has left the launch tube then he is free to either get another weapon round, to assemble another missile round for a further engagement (which takes less than 10 seconds), take cover or move to another location.

US Army training needs indicate that 136 hours of instruction are required on the Stinger system before weapon qualification is given. The M60 field handling and M134 tracker head training versions are used for instruction.

## Variants

### Air-to-air Stinger

In the late seventies General Dynamics began development of an Air-to-air Stinger (ATAS) system which completed its Full-Scale Engineering Development phase in late 1986. First production deliveries were made to the US Army in mid-1988 and the Flight Structure Division of the Western Gear Corporation was the subcontractor responsible for building the launcher structural assembly.

Weighing 55.9 kg fully loaded, the lightweight two-round launcher unit is available for use on US Army Bell OH-58A/C Kiowa (one launcher), Bell AH-58D Warrior (two), Sikorsky UH-60 Black Hawk (one), Hughes AH-64 Apache (two), Hughes AH-6F/G (one) and Bell AH-1 Cobra (one) helicopters. Fixed-wing aircraft such as the Rockwell OV-10 Bronco can also be outfitted with ATAS launchers on their underwing pylons. Operational deployment of ATAS by the US Army occurred in 1990 on the OH-58C, and is continuing on the OH-58D. Depending upon funding the US Army will also fit ATAS to a portion of its Apache fleet. The RAH-66 Comanche will have Stinger-RMP fitted in a specially developed Stinger Universal Launcher.

### Tripod-Mounted Stinger

General Dynamics has also privately developed the Tripod-Mounted Stinger system. This has four ready-to-fire missiles mounted on two ATAS launcher shoes at 90° to the vertical and is fitted with an integrated high magnification optical sight and a Marconi Forward Looking IR (FLIR) tracking system to allow Stinger launches at night and in bad weather. The one-man system weighs less than 136.4 kg and can be mounted on the rear of a vehicle if required.

It can also be interfaced with a higher echelon command and control network using positive gunner cueing and is fitted with automatic missile sequencing and seeker uncaging. Traverse capability is a full 360° and the elevation limits are -10 to +50°.

In late 1987 the Tripod-Mounted Stinger system was tested in South Korea for use in the airfield defence role. Growth potential includes the fitting of a laser rangefinder and a go/no go fire control computer.

### Pedestal-Mounted Stinger

This is fully described in the *Self-Propelled Surface-to-Air Missiles* section of this book.

### Magnavox Wide Angle Stinger Pointer (WASP)

Magnavox has developed a lightweight night sight attachment known as WASP which has been manufactured in small quantities against special orders. The sight has been adopted by the US Marine Corps as its definitive Stinger Night Sight. Three units were delivered for trials in August 1991 and orders for 530 are expected, together with another 100 plus for the US Special Operations Command.

Based on the company's Short-Range Thermal Sight technology with modifications to the scanner and objective lens to accommodate the Stinger launch envelope.

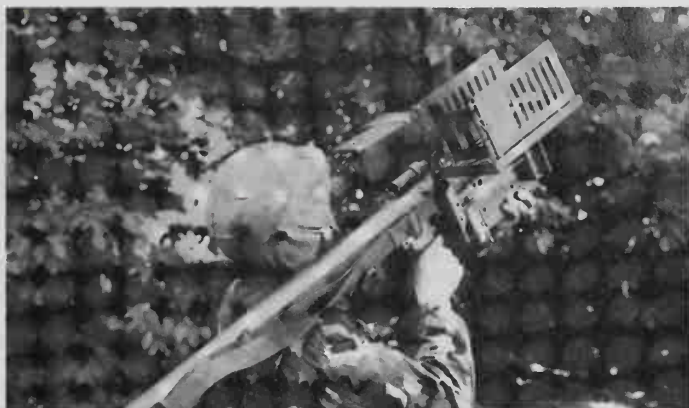
Total weight (including a BA 5847/U disposable lithium battery) is about 2.27 kg with dimensions of 292.1 × 101.6 × 152.4 mm. The field-of-view is 20° horizontal by 12° vertical with the viewing done using a fixed illumination reticle and the 3-5 µm spectral waveband region. Battery life is 10 hours. With a Ni/Cd battery the life is seven hours.

### Hughes Thermal Weapon Sight (TWS)

Hughes has adapted its TWS unit for a use on a number of weapon systems including the Stinger MANPADS. This is a thermo-electrically cooled passive forward-looking infra-red focal plane array sensor with an easily exchangeable telescope and graticule device for night time use.

### ITT Defence F4960 Stinger Night Sight

The Stinger Night Sight is a third-generation image intensifier system based on the AN/PVS-4 weapon sight technology. It incorporates a 60 mm, F1.2 objective lens (that provides a ×2.26 magnification and a 23.5° circular field-of-view) with a 25 mm Gen III+ F4844 image intensifier tube. The spectral response region is from 600 to 900 nm.



Stinger SAM system fitted with the Magnavox Wide Angle Stinger Pointer

Total length is 312.4 mm (386.1 mm with the mounting bracket attached), diameter 104.1 mm and weight 1.91 kg (2.27 kg with the bracket). The sight is powered by two AA size alkaline batteries which provide on average up to 30 hours of usage.

The illuminated tracking/aiming reticule has a fully adjustable brightness control and is similar to the existing Stinger reticule. The combination of the lens and image intensifier tube allows acquisition of targets at ranges of up to 7000 m and identification at 4500-5000 m even under starlight conditions.

A total of 150 examples of the sight have been supplied to the US Marine Corps as the interim Stinger Night Sight system. These were deployed in the Gulf War.

### LAV-Air Defence Gun/Missile System

The competitors for this US Marine Corps requirement are described in the *Self-Propelled Anti-Aircraft Guns* section of this book.

### Dornier Self-propelled Stinger

Details of this system developed by the German company of Dornier, are given in the *Self-Propelled Surface-to-Air Missiles* section.

### Stinger Motor Upgrade

In 1990, an improved motor was undergoing preliminary research and development by Atlantic Research Corporation. The motor is intended to provide significant improvements in the effective range and ceiling for the FIM-92C.

## SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	missile 1.52 m
DIAMETER	missile 0.070 m
WING SPAN	0.091 m
WEIGHTS	
missile (launch)	10.1 kg
launcher (plus missile)	13.3 kg
launcher (complete)	15.7 kg
battery coolant unit	0.4 kg
beltpack IFF system (including connecting lead)	2.6 kg
grip-stock	2 kg
PROPULSION	solid fuel ejector and boost/sustainer rocket motors
GUIDANCE	FIM-92A passive IR homing
WARHEAD	FIM-92B/C passive IR/UV homing
	3 kg HE-fragmentation with contact fuze
MAX SPEED	Mach 2.2
MAX RANGE	8000 m
MAX EFFECTIVE RANGE	
FIM-92A	greater than 4000 m
FIM-92B/C	greater than 4500 m
MIN EFFECTIVE RANGE	200 m
MAX ALTITUDE	
FIM-92A	3500 m
FIM-92B/C	3800 m
MIN ALTITUDE	effectively ground level
LAUNCHER	manportable single-round disposable with reusable grip-stock

**Status:** Basic Stinger, production complete with 15 669 rounds built. Stinger-POST, production complete with just under 600 rounds built. Stinger-RMP, in production at rate of over 750 missiles per month. On order or in service with the following countries:

Country	Service	Model	Country	Service	Model
Afghanistan	Mojahedin guerrillas	FIM-92A	Saudi Arabia	army	FIM-92A/C
Angola	UNITA guerrillas	FIM-92A	Switzerland	army	FIM-92C
Bahrain	army	FIM-92A	Turkey	army	FIM-92A
Chad	army (limited numbers)	FIM-92A	UK	Special Air Service (limited number)	FIM-92A
Denmark	army	FIM-92A	USA	Special Forces, army, navy, marine corps and air force	FIM-92A/B/C
France	army (limited numbers)	FIM-92A			
Germany	army, navy and air force	FIM-92A			
Greece	army	FIM-92A			
Israel	Army	FIM-92C			
Italy	army	FIM-92A			
Japan	air and ground self defence forces	FIM-92A			
Korea, South	army	FIM-92A			
Netherlands	army, navy and Marine Corps	FIM-92A			
Pakistan	army	FIM-92A			
Qatar	army	FIM-92A			

**Manufacturers:** General Dynamics, Air Defense Systems Division, PO Box 50-800, Ontario, California 91761-1085, USA  
Telephone: (714-) 945 7000

Second source supplier: Raytheon Company Missile Systems Division, Bedford, Massachusetts 01730, USA  
Telephone: (617) 274 222

Prime European contractor: Dornier GmbH, Postfach 1420, D-7990 Friedrichshafen 1, Federal Republic of Germany

## General Dynamics FIM-43 Redeye Low Altitude Surface-to-air Missile System

### Development

The development of a first-generation US shoulder-launched infra-red (IR) guided fire-and-forget surface-to-air missile was started in 1956 by Convair Pomona (subsequently General Dynamics Pomona) as a private venture project.

In 1957 the firm made an unsolicited proposal to the US Army concerning a system of this type and in 1958 was awarded a one-year feasibility demonstration contract. This led in mid-1959 to the evaluation of working models and, in August of that year, the company was awarded a joint US Army/Marine Corps contract covering the research and development of what became designated the XMIM-43A Redeye system. Although initial joint production funds were requested in FY61, numerous problems were encountered that resulted in the allocation being repeatedly postponed from year to year. Finally, in 1964, sufficient funds were made available for 300 systems to be produced for extensive operational testing to take place. The subsequent trials uncovered yet more problems including the need for a longer sensor warm-up time before firing could take place. These difficulties were finally resolved in 1965 and in October that year the first contract was placed with General Dynamics for full-scale production of the definitive FIM-43A Redeye for 1966 with first tactical deployments in 1967. By 1968 the first US Army and US Marine Corps units were considered to be fully operational. Production of the system continued until 1974 when the last of over 33 000 systems were delivered.

In US Army/Marine Corps service each manoeuvre battalion (depending upon its type) fielded a Redeye section with between four to six two-man firing teams. Each team comprised a commander and a gunner and was assigned a 1/4 ton M151 vehicle for mobility purposes. Due to its limited engagement capabilities as a first-generation tail-chase weapon against targets with speeds up to 740 km/h, the system has now been replaced in US front-line service by the much more versatile FIM-92 Stinger. The systems remaining in the inventory are being kept both as back ups for the Stinger until procurement of that system is complete and for training the low level air defence teams in live-firing and engagement techniques.

The first export customer for Redeye was the Swedish Army which started looking at the system in 1964 and eventually signed a contract in September 1966 for a batch of 10 with several training sets for trials purposes. Following a successful evaluation, the Royal Swedish Army Material Administration adopted the Redeye under the local designation Rb-69 (Robot-69) and ordered a further 1083 systems in 1967. Subsequent purchasers through the late sixties and seventies have included Australia (260 units), Denmark (243 improved propulsion FIM-43C units under the local designation Hamlet), Germany (1400 units under the local designation Fliegerfaust-1, FLF-1), Greece (100 units), Israel (over 1000 units), Jordan, Saudi Arabia (500 units), Thailand and Turkey. A number of these countries are currently replacing their Redeye systems with more modern second-generation manportable weapons.

In 1982 a batch of 100 Redeye firing units was delivered to Somalia as part of a military aid package given by the US Government in response to an Ethiopian attack across their common border. During 1984 a number of Redeye systems was supplied to the Sudanese government during the border crisis with Libya.

In 1984-85 small numbers of Redeye systems were given to the Afghanistan Mojahedin guerrillas. These destroyed a number of aircraft including Sukhoi Su-25K 'Frogfoot-A' attack aircraft.

Also in the mid-eighties, small numbers of Redeyes were supplied to the Chad government as part of the emergency military aid supplied by the US Government for use against Libyan combat aircraft and helicopters in the northern provinces conflict. Subsequently, in 1986, a number of surplus

Redeyes were also supplied to the US backed Contra guerrillas fighting the communist backed Sandinista government of Nicaragua. In both conflicts the weapon is known to have scored a number of kills. Examples of the weapon were captured by the Sandinistas during combat operations, with the first falling into their hands following a CIA supply drop in July 1987.

However, like contemporary first-generation weapons, the Redeye's capabilities against modern high performance combat aircraft has proved to be marginal with its best performances being shown, like the Soviet SA-7 'Grail', to be against the slower moving piston-engined transports and helicopters. First combat use was on 10 June 1982 by Israel, destroying a Syrian MiG-23.

### Description

The missile is sealed in its launcher and is not removed in the field before firing. It is fitted with an Atlantic Research M115 two-stage solid propellant rocket motor which acts as both the ejector and sustainer. The 2 kg warhead is an HE-fragmentation type and can be detonated when the contact fuze penetrates a metal object or physically meets a solid object. However, if no physical contact is made after 15 seconds of flight, a self-destruct circuit operates.

The Redeye system comprises three components: the M46A2 moulded material launcher assembly, the M41 missile and the launcher battery/coolant unit. The launcher includes an integral grip-stock fabrication, an open-sight aperture and cover and the missile launcher-container tube. The front end seal of the latter is transparent to IR radiation to allow the missile seeker to sense the target. No IFF interrogator system is fitted so target identification is undertaken by the gunner using solely visual means. Once he decides to engage he starts a sequence of actions which must not take longer than 30 seconds due to the active life of the battery unit.

The first is to insert the battery/coolant device into the launcher's receptor and then, when the target is in range, he engages the safety and actuator system which activates the battery/coolant unit and sends liberated Freon gas to the missile seeker where it expands to cool the IR detector. The  $\times 7.5$  magnification open-sight with its 25° field-of-view is then placed on the target. The sight is designed to allow the gunner to aim the system, track the target, estimate its range and apply target elevation all in one operation. Any IR radiation received from the target is then allowed to focus through the front-end seal onto the seeker's detector cell. When sufficient energy is received to enable a lock-on to be achieved, then audible and visual indicators are generated on the launcher to show the gunner that the missile has acquired its target. He then holds down the uncaging bar switch to uncage the weapon's gyro system, which has already been spun-up to speed, and depresses the firing trigger on the grip-stock. This causes an electric squib to ignite a thermite charge that melts an electrolyte in the battery which develops a 40 V output within 0.5 seconds. The missile ejector motor fires and the exhausting gas breaks through the rear frangible end cover seal, impinges on the folded tail fins and causes the weapon to spin within the tube. Once an acceleration of 28 g is reached an inertial switch in the fuze timer closes and the fuze timer circuit becomes live. The ejector motor burns out in a fraction of a second before the missile totally emerges through the front seal cover in order to protect the gunner from blast burns. During this brief coasting phase from the launcher muzzle, the four fixed tail fins and the two movable nose fins deploy. At 1.6 seconds into the flight and approximately 6 to 7 m in front of the gunner's position the timer fuze circuit ignites the second-stage sustainer motor, arms the warhead and prepares it for detonation.

In the meantime the conical optical IR seeker is continually measuring the difference between the gyro line-of-sight and the IR source it is looking at. This data is converted into electrical tracking error signals which are then used in a tracking servo-loop to continuously re-position the seeker so that it stays aimed at the target. The use of this tail-chase proportional





General Dynamics FIM-43 Redeye manportable surface-to-air missile system complete with grip-stock (German Army)

navigation guidance technique means that any violently manoeuvring target, especially if it is employing IR decoy systems to screen itself, has a very good chance of breaking the seeker lock and evading the weapon.

During the flight, canted nozzles impart roll to the missile which allows a single-axis control system to be used. The pair of movable 15° canted control fins near the nose are then commanded to snap in and out as required by this system, which is directed by the tracking error guidance signals already generated by the seeker's IR homing package. Once in contact with the target the titanium warhead is detonated by its fuze using either of the two contact methods described previously to burn through the target skin and start internal fires. If it fails to hit a target after its set flight time then the warhead automatically self-destructs, although if this happens to be near an aircraft then serious damage can still occur. After missile firing occurs the launcher and attachments are discarded and the gunner obtains a new system for the next engagement. Typical response time from the target entering the detection range to missile launch is 10 seconds. The reaction time between the detonation of one missile and the launch of a second missile by the same gunner at the same target is also 10 seconds.



US soldier using General Dynamics FIM-43 Redeye manportable missile (US Army)

#### SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	
missile	1.283 m
launcher (complete)	1.283 m
DIAMETER	
missile	0.070 m
launcher (without cover, sling or battery/coolant unit)	0.092 m
WING SPAN	0.140 m
WIDTH	
launcher (complete)	0.119 m
HEIGHT	
launcher (complete)	0.277 m
WEIGHTS	
missile (launch)	8.2 kg
launcher (complete)	13.1 kg
launcher (without cover, sling or battery/coolant unit)	3.9 kg
battery/coolant unit	0.5 kg
PROPULSION	solid fuel dual thrust ejector and sustainer rocket motor
GUIDANCE	infra-red passive homing
WARHEAD	2 kg HE-fragmentation with contact fuze
MAX SPEED	Mach 1.6
MAX EFFECTIVE RANGE	5500 m
MIN EFFECTIVE RANGE	500 m
MAX ALTITUDE	2700 m
MIN ALTITUDE	effectively ground level
LAUNCHER	manportable single-round disposable

**Status:** Production complete. In service with Afghanistan Mojahedin, Chad (Army), Denmark (Army), El Salvador (FMLN guerrilla group), Germany (Army), Greece (Army), Israel (Army and Navy), Jordan (Army), Nicaraguan Contra guerrillas, Saudi Arabia (Army), Somalia Army, Sudan (Army), Thailand (Army), Turkey (Army) and the USA (second-line with Army, Marine Corps, Navy and Air Force units).

**Manufacturer:** General Dynamics, Air Defense Systems Division, PO Box 50-800, Ontario, California 91761-1085, USA.  
Telephone: (714) 945-7000

## YUGOSLAVIA

## SPDR Strela-2M/A Low Altitude Surface-to-air Missile System

## Development/Description

The Strela-2M/A (Yugoslavian military designation S-2M/A) is a locally built derivative of the Soviet Strela-2M (qv SA-7b 'Grail' Mod 1 entry this section) manportable surface-to-air missile system.

The S-2M/A varies from the Soviet model in that the electronic systems in the single channel passive infra-red seeker have been miniaturised, allowing the warhead section to be enlarged and increased in weight by 20 per cent with the following advantages when compared to the standard Strela-2M warhead:

- (a) a 40 per cent increase in the weight of the explosive charge carried (0.518 kg versus 0.37 kg)
- (b) a 40 per cent increase in the blast effects
- (c) a 30 per cent increase in the overall fragmentation effect
- (d) a 30 per cent increase in the total warhead efficiency
- (e) a 0.2 per cent increase in the Single Shot Kill Probability figure.

All the other tactical and technical details are identical to the Strela-2M.

The Strela-2M/A is used by all the factions involved in the Yugoslavian internal unrest.

## SPECIFICATIONS

TYPE	two-stage low altitude
LENGTH	
missile (fins folded)	1.440 m
launch tube	1.500 m
DIAMETER	
missile	0.072 m



Yugoslav built Strela 2M/A surface-to-air missile deployed in firing position

## WEIGHT

total launcher assembly	15 kg
at firing position	16 kg
in travelling position	
launch tube	3 kg
grip-stock plus battery	1.95 kg
battery	0.66 kg
missile at launch	9.85 kg

## PROPULSION

solid fuel booster and solid fuel sustainer rocket motor

## GUIDANCE

single channel passive infra-red homing

## WARHEAD

1.32 kg HE-smooth fragmentation with contact and graze fuzing  
500 m/s

## AVERAGE MISSILE SPEED

## MAX FIRING RANGE

receding target	4200 m
approaching target	2800 m

## MAX TARGET ENGAGEMENT SPEED

receding target	260 m/s
approaching target	150 m/s

## MAX EFFECTIVE

## TARGET ALTITUDE

2300 m

## MIN EFFECTIVE

## TARGET ALTITUDE

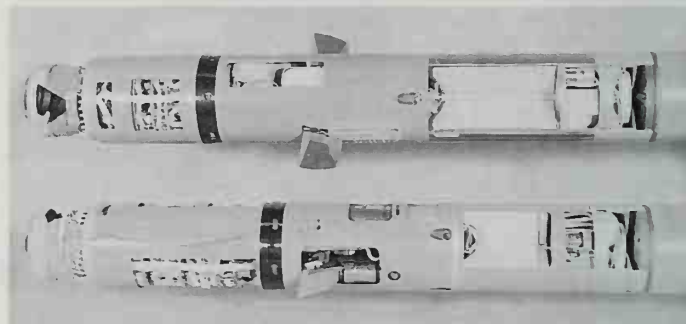
50 m (can be down to 15 m but missile may be seduced by horizon and ground radiative heat effects)

## LAUNCHER

manportable single-round disposable with grip-stock

**Status:** Production complete. In service with the Croatia militia, Serbian militia, Slovenian Civil Defense (TO, Teritorijalna obramba) and the Yugoslavian Army and offered for export.

**Manufacturer:** Enquiries to Federal Directorate of Supply and Procurement, Yu-11105 Beograd, 9 Nemanjina St, Yugoslavia.  
Telephone: 621 522/326 851  
Telex: 11360/11541/11591/11821 YU SDPR  
Cable: DIRPROM, POB 308  
Fax: 38 11 635 702



Comparison cross-sections of Strela-2M/A (top) and Strela-2M (bottom) steer and control units with warhead size



# Self-Propelled Anti-Aircraft Guns

(This section also includes self-propelled anti-aircraft guns which are fitted with SAMs to engage aircraft targets at longer ranges)

## CHINA, PEOPLE'S REPUBLIC

### NORINCO Type 80 Twin 57 mm Self-propelled Anti-aircraft Gun System

#### Development

The Type 80 twin 57 mm self-propelled anti-aircraft gun system was developed for use by armoured and mechanised infantry units to provide defence against air attack at slant ranges of up to 5500 m by targets flying at speeds of up to 350 m/s. If required the vehicle can also be used in the ground role to support conventional anti-tank weapons. The system consists of a modified Type 69 II MBT chassis fitted with a Chinese version of the Soviet turret installed on the Soviet ZSU-57-2 twin 57 mm self-propelled anti-aircraft tank, but using a twin-barrel variant of the locally produced Type 59 which is itself a copy of the Soviet single S-60 57 mm towed anti-aircraft gun. The weapons can be fired while on the move or on slopes of up to 15° but the best results are obtained when it is stationary on the ground with a slope of 3° or less.

#### Description

The hull of the Type 80 is divided into three compartments: driver at the front, fighting in the centre and engine at the rear.

The driver sits at the front of the hull on the right and has a single-piece hatch cover that opens to the left. An infra-red periscope is fitted for night driving together with a normal optical viewing periscope.

The open-topped welded steel turret is mounted in the centre of the chassis. A wire cage, mounted externally at the turret rear, is provided for the empty cartridge cases and links.

The main armament consists of two Type 59 57 mm cannon with their control system used either in a semi-automatic, electrohydraulic powered manner or manually. In the former mode the elevation is from -1 to +81°, in the latter it is -5 to +85°. Fire control is by an automatic optical vector mode sight. A crew of five is carried in the turret: commander, gunner, fuze-setter and two loaders. For internal crew communication a Type 803 intercom system is fitted. A 20-25 km range Type 889 radio is standard for external communications.

The guns are fully automatic and recoil operated with each barrel having a maximum cyclic rate of fire of 105 to 120 rds/min. The practical rate of fire is 70 rds/min. Maximum horizontal range is 12 000 m, maximum vertical range 8800 m and effective anti-aircraft range 5500 m. The guns fire two

types of fixed ammunition; a 6.47 kg high explosive tracer (HE-T) round with a percussion fuze and a 6.45 kg armour-piercing capped tracer (APC-T) round with a base fuze. A self-destruct device is incorporated into the HE-T shell to ensure automatic detonation after 6000 m of flight. A total of 300 rounds is carried.

It has torsion bar type suspension with five road wheels (the Soviet equivalent ZSU-57-2 has only four), idler at the front, drive sprocket at the rear and no track return rollers. Unlike the Soviet ZSU-57-2 the Type 80 is fitted with track skirts.

#### SPECIFICATIONS

CREW	6
COMBAT WEIGHT	31 000 kg
POWER-TO-WEIGHT RATIO	18.7 hp/t
LENGTH	
guns forward	8.42 m
guns rear	8.24 m
hull	6.243 m
WIDTH	
with fenders	3.27 m
with side skirts	3.307 m
HEIGHT	2.748 m
FIRING HEIGHT	1.94 m
GROUND CLEARANCE	0.425 m
TRACK	2.64 m
TRACK WIDTH	580 mm
LENGTH OF TRACK ON GROUND	3.485 m
MAX ROAD SPEED	48-50 km/h
MAX ROAD RANGE	420-440 km
FORDING	1.4 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.8 m
TRENCH	2.7 m
ENGINE	Model 12150 - 7BW diesel developing 580 hp at 2000 rpm manual with 5 forward and 1 reverse gears clutch and brake torsion bar
TRANSMISSION	
STEERING	
SUSPENSION	
ELECTRICAL SYSTEM	28 V
BATTERIES	4 × Type 65 12 V, 280 Ah
ARMAMENT	2 × 57 mm guns
AMMUNITION	300
GUN CONTROL EQUIPMENT	
turret power control	powered/manual
max gun elevation/depression	+85°/-5°
turret traverse	360°
ARMOUR	
hull glacis	45 mm
hull rear	30 mm
hull upper	20 mm
hull lower	20 mm
hull side	20 mm
turret (all-round)	12 mm curved

**Status:** Production as required. In service with the Chinese Army.

**Manufacturer:** Enquiries to China North Industries Corporation, 7A Yuetan Nanjie, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3471, 7570  
Telex: 22339 CNIN CN



Type 80 twin 57 mm self-propelled anti-aircraft gun system with turret traversed to front

## NORINCO Twin 37 mm Self-propelled Anti-aircraft Gun System

### Development

The existence of a new twin 37 mm self-propelled anti-aircraft gun system was first disclosed in 1986 and at that time a single prototype had been built and evaluated by the Chinese Army. As far as it is known the system has yet to enter production. This system has been developed by China North Industries Corporation (NORINCO).

### Description

It consists essentially of a modified Type 69 MBT (technical details of which are given in the previous entry) fitted with a new two-man all-welded steel turret armed with the Type 76 twin 37 mm gun system originally developed for naval applications. Each cannon is provided with 250 rounds of ready use ammunition.

Turret traverse is powered through a full 360° at a maximum of 60°/s while the twin 37 mm cannon can be elevated from -10° to +87° at a maximum speed of 50°/s. Turret traverse and weapon elevation is electric with manual controls being provided for emergency use.

The turret is fitted with a Type JM832 fire control system with the gunner laying the turret and weapons onto the target using a joystick and an optical sight which can track aircraft flying at speeds of between 50 and 350 m/s.

The lead angle is calculated by means of a computer and when the target is within range the joystick is depressed to fire the twin 37 mm cannon.

The optical sight has a magnification of  $\times 5$  and a 12° field-of-view. This is a clear weather system only with no provision for off carriage fire control.

Each 37 mm cannon has a cyclic rate of fire of 360-380 rds/min with the Type 76 HE-T being the standard air defence round. The complete round weighs 1.8 kg with the projectile weighing 0.741 kg and is fitted with a tracer that lasts about eight seconds. Muzzle velocity is 1000 m/s with ammunition being belt fed.

According to NORINCO the weapons have a maximum slant range of 10 000 m with effective slant range of 7200 m, maximum altitude is quoted as 7200 m. Its practical range in the air defence role is however around 4000 m.

The system has a combat weight of 35 000 kg with a maximum road speed of 50 km/h and a maximum road range of 420 km.

### Variant

During a defence exhibition held in Beijing in late 1988, another twin 37 mm self-propelled anti-aircraft gun was shown in public for the first time. It had a slightly different power operated turret and was armed with the same twin 37 mm cannon which were fitted with flash suppressors. They have a cyclic rate of fire of 360 to 380 rds/barrel/min with a total of 500 rounds of ready use ammunition being carried.

The turret is fitted with a fire control system and a roof-mounted surveillance radar system. When not required the latter folds down towards the rear.

The four man crew consists of the vehicle commander, gunner, tracker and driver who is seated in the front of the hull on the left side.

NORINCO state that this system has been designed to engage air targets flying below an altitude of 3000 m with a slant range of 3800 m and with a maximum speed of 350 m/s. It can also be used to engage ground targets and has an ECCM capability.



Close up of turret rear of new Chinese twin 37 mm self-propelled anti-aircraft turret with radar retracted



Twin 37 mm self-propelled anti-aircraft gun system on Type 69 series MBT chassis



New Chinese twin 37 mm self-propelled anti-aircraft gun system fitted with target surveillance radar on the turret roof towards the rear (Eric Ditchfield)

The fire control system comprises the roof-mounted surveillance radar with a rangefinding function, an inquiry system used in conjunction with the search radar, an electro-optic co-ordinate device (which includes a periscope type tracking sight, laser rangefinder and a fire control operating mechanism), a resolver, periscope type light-ring sight and an optical target indicator. Typical target response times have been quoted as 6 to 12 seconds with sufficient fuel being carried for eight hours of continuous operations.

Turret traverse is 360° at a maximum speed of 60°/s while elevation is from -10° to +87° at a maximum speed of 40°/s.

The search radar has a maximum range of about 15 km up to 3000 m and rotates at 30 rpm. The electro-optic co-ordinate device has a magnification of  $\times 6$  and a 10° field-of-view with traverse and elevation speeds being 60°/s. The laser rangefinder has a maximum range of 8000 m. The periscope type light-ring sight has an anti-aircraft magnification of  $\times 1.5$  and a ground magnification of  $\times 5$  with fields-of-view of 13° and 50° respectively. Five target setting speeds are available. The optical target indicator has a magnification of  $\times 1$  and a 15° field-of-view.

The system has five modes of operation:

- (1) Searching for targets with the radar, tracking with the electro-optic co-ordinating device, laser rangefinding, firing data output by the resolver and firing by servo-driven guns
- (2) Searching for targets with the radar, the radar is converted into tracking and rangefinding by the electro-optic co-ordinate device, firing data output by the resolver and firing by the servo-driven guns
- (3) Indicating target with the optical target indicator, tracking with the electro-optic co-ordinate device, laser rangefinding, firing data output by the resolver and firing by the servo-driven guns
- (4) Indicating target with the onboard optical target indicator, tracking with the electro-optic co-ordinate device, setting target distance, speed and route shortcut, firing data output by the resolver and firing by the servo-driven guns



(5) Indicating target with the optical target indicator, tracking with the light-rising sight and firing by the servo-driven guns.

Standard onboard equipment includes a radio system with a maximum range of 25 km, internal communications system and a navigation system.

The system weighs 35 000 kg fully loaded, has a maximum road speed of 50 km/h and a maximum cruising range of 420 km.

**Status:** Development complete. Ready for production.

**Manufacturer:** Enquiries to China North Industries Corporation, 7A Yuetan Nanjie, Beijing, People's Republic of China.

Telephone: (86) 6898, 3461, 3471, 7570

Telex: 22339 CNIN CN

## Type 63 Twin 37 mm Self-propelled Anti-aircraft Gun System

This system is essentially a T-34/85 tank chassis with a modified turret armed with twin 37 mm anti-aircraft guns. It was first encountered in South

Vietnam but is thought to be no longer in service, and was probably a local modification rather than a system produced in large quantities. Details of the system were given in *Jane's Land-Based Air Defence 1990-91* pages 62/63.

## CZECHOSLOVAKIA

### M53/59 Twin 30 mm Self-propelled Anti-aircraft Gun System

#### Development

The M53/59 self-propelled anti-aircraft gun was introduced into the Czechoslovakian Army in the late 1950s and consists of an armoured version of the standard Praga V3S (6 × 6) truck with a removable modified version of the standard towed M53 twin 30 mm anti-aircraft guns mounted on the rear. The guns are often removed for ground use. The mounting has also been seen on the PTS unarmoured tracked amphibious vehicle.

#### Description

The M53/59 has an all-welded hull with the engine at the front, crew compartment in the centre and the armament at the rear. The hull armour is well sloped for maximum possible protection within the weight limit available. The driver is seated on the left side and the commander on the right, with a windscreen in front of them which is covered in action by an armoured cover, hinged at the top, with a vision slit. Both the driver and commander also have a door in the side of the hull, the top half of which has a vision slit and hinges downwards on the outside. The two loaders are seated one either side at the back of the crew compartment facing the rear and have a vision slit in the side, immediately behind the side door. At the rear of the crew compartment is a two-piece hatch cover which folds down into the horizontal to act as a platform for the loaders. It has a single vision slit in either side for the loaders. The commander has a hemispherical plexiglass cupola in the roof for observation.

The weapons have an elevation of +85° and a depression of -10°, except over the crew compartment where depression is limited to +2°, and over the commander's cupola where there is none. A steel plate at the rear of the crew compartment stops the gun barrels hitting the roof. The turret can be traversed a full 360° and elevation, depression and traverse are all hydraulic with manual controls available for emergency use. The gunner is seated on the left side of the weapons and has frontal, side and rear armour protection. When originally introduced the barrels had multi-baffle muzzle brakes but more recently the weapons have been observed fitted with conical flash-hiders. The barrels can be quickly changed when they become overheated and spare barrels are kept at regimental level as part of basic equipment.

The twin 30 mm cannons are fully automatic gas-operated weapons and have a cyclic rate of fire of 450 to 500 rds/barrel/min and a practical rate of fire of 150 rds/barrel/min. Maximum horizontal range is 9700 m, maximum vertical range is 6300 m and effective anti-aircraft range is 3000 m. Each of the vertical magazines holds 50 rounds of ammunition which is fed to the

magazines in clips of 10 rounds. The towed M53 twin 30 mm guns have a lower rate of fire as they have no magazines and the ammunition has to be fed to each weapon in clips of 10 rounds. The following types of fixed ammunition can be fired by the 30 mm guns:

API projectile weighing 0.45 kg, with a muzzle velocity of 1000 m/s, which will penetrate 55 mm of armour at an incidence of 0° at a range of 500 m; HEI projectile weighing 0.45 kg with a muzzle velocity of 1000 m/s.

The Yugoslav Federal Directorate of Supply and Procurement manufactures ammunition for the M53/59 twin 30 mm SPAAG system which it calls the anti-aircraft gun 30/2 mm M53, 53/59 (CS). Two types of ammunition are manufactured: HE-T, designated the M69, and cartridge, blank, designated M78. Details of these are as follows:-

DESIGNATION	M69	M78
TOTAL LENGTH	331 mm	331 mm
WEIGHT	1.14 kg	0.96 kg
MUZZLE VELOCITY	997 m/s	n/av
MAX PRESSURE	3140 bar	1760 bar
WEIGHT OF PROJECTILE	435 g	250 g
CARTRIDGE CASE	steel	steel
PROPELLING CHARGE	NC powder	NC powder

The M69 has a tracer which burns for four seconds and is fitted with an impact super-quick action fuze with mechanical self-destruct. The M78 has a maximum range of 120 m.

Filled magazines are carried in the rear of the crew compartment fastened to the floor by quick-release catches, a further three filled magazines are carried either side of the platform.

Stowed under the rear of the vehicle are two ramps which assist the crew in deploying the system when it is being used in the ground role. When in the latter role the mount is stabilised on four jacks. A winch is provided to haul the mount back onto the vehicle via the ramps.

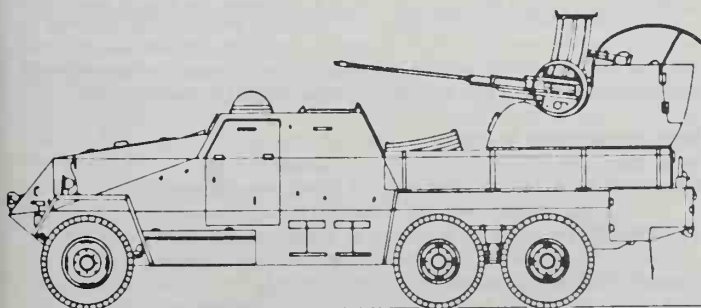
The main drawback of this system is its lack of all-weather capability. The vehicle has no NBC system, no night vision equipment, no amphibious capability and no central tyre-pressure regulation system.

#### Variants

In recent years Czechoslovakia has offered an export version of the M53/59 called the M53/70, which appears to be almost identical to the earlier version but with an improved fire control system.

#### SPECIFICATIONS

CREW	4
CONFIGURATION	6 × 6
COMBAT WEIGHT	10 300 kg
POWER-TO-WEIGHT RATIO	11.57 hp/t
LENGTH	6.92 m
WIDTH	2.35 m
HEIGHT	
including magazines	2.95 m
excluding magazines	2.585 m
FIRING HEIGHT	2.41 m
GROUND CLEARANCE	0.4 m
TRACK	
front	1.87 m
rear	1.755 m
WHEELBASE	3.58 m + 1.12 m
MAX ROAD SPEED	60 km/h
FUEL CAPACITY	120 l
MAX ROAD RANGE	500 km
FUEL CONSUMPTION	0.24 l/km



M53/59 twin 30 mm self-propelled anti-aircraft gun (provisional drawing)

FORDING	0.8 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.46 m
TRENCH	0.69 m
ENGINE	Tatra T 912-2 6-cylinder in-line air-cooled diesel developing 110 hp at 2200 rpm manual with 4 forward and 2 reverse gears
TRANSMISSION	2-speed
TRANSFER BOX	8.25 × 20
TYRES	2 × 30 mm cannon
ARMAMENT (main)	600-800
AMMUNITION	hydraulic/manual
GUN CONTROL EQUIPMENT	+85°/-10°
turret power control	360°
gun elevation/depression	10 mm max (estimated)
turret traverse	
ARMOUR	

**Status:** Production complete. In service with Czechoslovakia, Libya and Yugoslavia.

**Manufacturers:** Chassis: Avia Závody, Letňany, Czechoslovakia. Armoured body, armament and final assembly: Czechoslovakian state arsenals.



*M53/59 twin 30 mm SPAAG in travelling configuration*

## EGYPT

### Dassault Electronique Sinai 23 Twin 23 mm Self-propelled Anti-aircraft Gun

#### Development

In January 1984 the Egyptian Government awarded competitive contracts to the Electronic Systems Division of Thomson-CSF and Dassault Electronique for the development and construction of prototypes of a twin 23 mm self-propelled anti-aircraft gun system.

Both systems were completed in 1984 and shown for the first time at the 1984 Cairo Defence Equipment Exhibition. They are based on the FMC M113A2 APC chassis and use the Soviet-designed 23 mm ZU-23 light anti-aircraft gun, now manufactured in Egypt by Military Egyptian Factory Abu Zaabal, and fully described in the *Towed Anti-Aircraft Guns* section.

A typical Sinai 23 platoon would consist of one leader vehicle fitted with the RA-20S radar and three or four satellite fire units each with twin 23 mm cannon. The Egyptian Air Defence Command conducted extensive trials of the weapon system in Egypt over a six month period in 1986. These trials, which included operating the system in a jammed environment (ground-based and airborne jammers) demonstrated that the system was easy to operate, targets could be quickly detected and the system had very short reaction, acquisition, designation and turret tracking times.

Following these trials the system was adopted by the Egyptian Air Defence Command and first units were delivered to Egypt in 1989.

#### Description

The acquisition/surveillance vehicle has the RA-20S radar operating in the E-band which can detect aircraft and moving helicopters at a range of 12 km or helicopters hovering at a range of 5 km. Targets can be localised to one degree. This vehicle provides target information to the firing unit.



*Sinai 23 firing unit showing power-operated turret armed with twin 23 mm cannon, three Sakr Eye SAMs either side of turret and RA-20S radar on turret rear*



*Sinai 23 firing unit showing one-man turret armed with two 23 mm cannon and six Sakr Eye SAMs*

The firing unit consists of an M113A2 fitted with a TA-23E turret which is a further development of the TA-20 turret armed with twin 20 mm cannon which is also fitted on the Panhard M3 (4 × 4) air defence system and VDAA Renault covered later in this section. The turret has full hydraulic traverse and weapon elevation and is armed with two 23 mm cannon with three Egyptian-built Sakr Eye (the locally built version of Soviet SA-7 (9M32) 'Grail' passive infra-red homing missile) fire-and-forget surface-to-air missile launchers mounted either side of the turret. Details of the Sakr Eye missile are given in the *Manportable Surface-to-Air Missile Systems* section under Egypt. When travelling the pod of three missiles is normally swung down to rest alongside the 23 mm cannon and is raised into the horizontal position when required. The gunner has an optical sight with a magnification of × 6 and a computer. Information can be received from the acquisition/surveillance vehicle positioned up to 2000 m away. Each cannon has 300 rounds of ready use ammunition. The vehicle commander with his control console sits at the rear of the vehicle on the left side to the rear of the driver.

The Sinai system is of modular construction and can be coupled to thermal and infra-red night vision systems. The firing unit can also be fitted with the RA-20S radar system so enabling two targets to be engaged simultaneously by the four vehicles (one leader and three satellites).

#### SPECIFICATIONS (Turret)

DESIGNATION	TA-23E
ARMAMENT	2 × 23 mm cannon 2 × 3 SAM missiles
AMMUNITION	2 × 300 ready-use 600 × 23 mm reserve
TURRET POWER CONTROL	hydraulic
SIGHT	day, magnification × 6
REACTION TIME	5 s (total)
DATA TRANSMISSION RANGE	up to 2 km



RADAR TYPE	pulse Doppler
DETECTION RANGE	12 km (moving targets) 5 km (hovering helicopters)
TARGET LOCALISATION	1°

#### Variants

Dassault Electronique is studying the installation of the Sinai 23 turret system on the Fahd (4 × 4) APC currently in production in Egypt for both the home and export markets. Details of the other competitor in this programme, the Thomson-CSF Nile 23 twin 23 mm self-propelled anti-aircraft gun system,

also based on an M113A2 full tracked armoured personnel carrier, are given in the following entry as this is still being marketed.

**Status:** In production for Egyptian Air Defence Command with first units now being delivered.

**Manufacturer:** Dassault Electronique, 55 quai Marcel Dassault, F-92214 Saint Cloud, France.

Telephone: (1) 49 11 80 00

Telex: 633 299 F

## FRANCE

### Thomson-CSF Nile 23 Twin 23 mm Self-propelled Anti-aircraft Gun

#### Development

In January 1984 the Egyptian Government awarded a contract to the Electronics Systems Division of Thomson-CSF for the development and construction of prototypes of a twin 23 mm self-propelled anti-aircraft gun system. A similar contract was awarded to Dassault Electronique (qv). The first prototype system was completed in 1984 and shown for the first time at the Cairo Defence Equipment Exhibition held in late 1984.

The system is based on the FMC M113A2 APC chassis which is widely used by the Egyptian Army and takes the Soviet designed 23 mm ZU-23 light anti-aircraft gun system which is now manufactured in Egypt by Abu Zaabal Engineering Industries and fully described in the *Towed Anti-Aircraft Guns* section.

The Nile 23 successfully completed a series of validation test firings in mid-1986.

Late in 1987, the Egyptian Air Defence Command requested that two Sakr Eye surface-to-air missiles (qv *Manportable Surface-to-Air Missile Systems* section) be mounted on either side of the turret in order to obtain a self-propelled twin 23 mm/Sakr Eye air defence system. Trials of the new combination were completed in 1989 with guns and missiles firing.

A typical Nile 23 battery would consist of one acquisition unit and four, six or eight firing units. When originally announced, Thomson-CSF called the Nile 23 the 'Dagger'.

Although Egypt subsequently selected the competing design by Dassault Electronique, Thomson-CSF are still marketing this system to other potential customers.

#### Description

The acquisition unit consists of an M113A2 APC with a Thomson-CSF pulse Doppler surveillance radar operating in the S-band with a detection range of 18 km and ensuring surveillance, threat evaluation and target designation functions.

The fire unit includes an M113A2 APC which is a modified version of the 23 mm ZU-23 towed anti-aircraft gun fitted with a roof-mounted armoured cab. Two Egyptian-built Sakr Eye (passive infra-red homing missile) fire-and-forget surface-to-air missile launchers are located either side of the turret. Typically, the missiles would be used to engage targets at longer ranges with the guns being used to engage closer range targets. The turret has full powered elevation and traverse, the latter at a maximum of 180° in three seconds, a local optical sight and a computer with automatic data processing. Each 23 mm cannon has a box of 50 or 100 rounds of ready use ammunition with 1200 rounds of ammunition carried inside of reloading.

According to Thomson-CSF, Nile 23 has an effective range capability of

3000 m with the acquisition unit capable of being deployed up to 5000 m away from the firing units.

#### Options

Nile 23 is a modular system, especially the fire control system allowing it to be tailored to meet specific user and operational requirements.

An acquisition unit can be used to control weapons of different calibres installed on tracked, wheeled or standard towed chassis. The fire control can also receive its target designation data from a Crotale SAM acquisition unit or from a target designator helmet.

In its backup mode, the 23 mm firing unit can operate independently as it has its own simplified fire control system.

**Status:** Development complete. Ready for production on receipt of firm orders.

**Manufacturer:** Thomson-CSF, Division Systèmes Électroniques, 9 rue des Mathurins, BP 150, F-92223 Bagneux Cedex, France.

Telephone: (1) 40 84 40 00

Telex: THOM616780F



Thomson-CSF Nile 23 twin 23 mm self-propelled anti-aircraft gun system (left) with Thomson-CSF acquisition unit (right), both systems being mounted on a modified M113 series APC chassis

### Thomson-CSF AMX-13 and AMX-30 DCA Twin 30 mm Self-propelled Anti-aircraft Gun Systems

#### Development

The first prototypes of the system, called the AMX-13 Defense Contre Avions (or DCA), were completed in 1960 but were not fitted with the radar system. The first prototype with the radar system was completed in 1964 and tested by the French Army from 1965 to 1966. These trials were satisfactory and the French Army subsequently placed an order for 60 production vehicles which were delivered between 1968 and 1969.

The French Army has two types of low level air defence regiment. The first has four batteries each with two troops, and having four Euromissile Roland surface-to-air missile systems on a GIAT Industries AMX-30 chassis. The second type has three Roland batteries plus one battery with four troops, each of which has three twin 30 mm AMX-13 DCA self-propelled anti-aircraft gun systems. With the introduction of the Matra Mistral

manportable SAM system into the French Army the AMX-13 DCA is expected to be phased out of service in the near future.

#### Description (AMX-13 DCA)

The DCA system consists of an AMX-13 type chassis, almost identical to that used for the 105 mm Mk 61 self-propelled howitzer, with a SAMM S401A turret mounted at the rear carrying the optical, electrical and hydraulic systems for laying the guns onto the target and firing the two Hispano-Suiza HSS-831A 30 mm automatic cannon, and a Thomson-CSF coherent pulse Doppler DR-VC-1A (Oeil Noir 1) radar mounted on the rear.

The driver is seated at the front of the vehicle on the left and has a single-piece hatch cover that opens to the rear, in front of which are three periscopes. The other two crew members are in the turret with the commander on the left and the gunner on the right. The chassis is identical to that of the 105 mm Mk 61 self-propelled howitzer.

When travelling the radar is normally retracted into its lightly armoured box on the turret rear and when raised provides omnidirectional search with



AMX-13 DCA twin 30 mm self-propelled anti-aircraft gun with radar erected. This is the model in service with the French Army

a high information rate, angular bearing acquisition of a target and accurate and continuous measurement of the distance of the selected target. This information is supplied by the radar, which operates in the D-band, in two modes of operation: search (omnidirectional or sectorised) and rangefinding. A corrector, supplied with information coming from the radar (distance), from tele-control (target speed) and various computational terms, computes the offset to be applied between the line-of-fire and the line-of-sight to ensure that the weapons are aimed at the target. This correction is introduced automatically into the aiming chains.

A typical target is engaged as follows:

**Phase 1 Omnidirectional Watch:** This is the responsibility of the commander who monitors the plan position indicator (PPI) inside the turret. The radar scanner rotates at 60 rpm and supplies information on the PPI tube from target echoes with radial velocities of between 50 to 300 m/s, in receiver range selection gates of 4.5 km, 7.5 km, 10.5 km and 13.5 km.

**Phase 2 Bearing Acquisition:** When a target, located in Phase 1, is considered a threat by the commander, he rotates the turret in its direction by means of a radial alidade which represents the turret axis on the PPI. Bearing acquisition is obtained when the alidade is brought into coincidence with the target echo. At the end of this phase the radar scanner, which is then set in the direction of the target, makes a sector scan about this position over an angle of about 30° to obtain more information. As the target changes position the commander gradually corrects the direction of the turret to hold its axis in line with the direction of the target.

**Phase 3 Elevation Optical Acquisition:** By the end of phase 2 the sight line is directed in bearing on the target. The gun layer then takes over control of the turret and scans in elevation, so acquiring the target.

**Phase 4 Rangefinding:** By the end of the three previous phases, target designation (bearing and elevation speed) has been obtained and there remains only to obtain the exact target distance which is measured by operating the radar in the rangefinding mode: a rangefinding gate locks onto the target echo enabling the target distance to be transmitted

continuously to the corrector. At the same time it is displayed in luminous form in the sight of the commander who can thus check the approach of the target while identifying it.

**Phase 5 Firing:** During this phase the corrector is supplied with the bearing and elevation target speed and target distance data previously obtained. The gun layer introduces the correction in the sight and remote-control chains. He continues to aim on the target while the guns are offset by such an angle that they are laid on the future target. The guns can be fired as soon as the target enters the optimum range of the weapons. The burst of the weapons is automatically adjusted to a number of salvoes preselected by limiters. Maximum range of this phase is 3800 m.

The two HSS-831A 30 mm guns have an elevation of +85°, depression of -5° and turret traverse is 360°. Gun elevation and turret traverse are hydraulic with manual controls provided for emergency use. The gunner can select single shot, 5- or 15-round bursts, or full automatic from either left or right gun, or both together. The weapons have a cyclic rate of fire of 600 rpm per barrel and each weapon has 300 rounds of 30 mm ammunition which is belt fed. Effective range of the weapons is 3500 m and the empty cartridges and links are ejected outside the turret.

The weapons can fire the following types of fixed 30 mm ammunition:

DESIGNATION (NATO)	SAPHEI/T	HEI/T	HEI	TP/T	TP
WEIGHT (g)					
projectile	360	360	360	360	360
explosive	18	26	36	n/app	n/app
propellant	160	160	160	160	160
complete round	870	870	870	870	870
MUZZLE VELOCITY (m/s)	1080	1080	1080	1080	1080

The commander and gunner both have a single-piece hatch cover that opens to the outside of the turret. APX L794 observation periscopes and an APX M250 periscope for using the weapons in the ground-to-ground role. The commander and gunner have SAGEM optical sights with a magnification of  $\times 1$  and  $\times 4$  respectively for anti-aircraft use. The turret is equipped with an air-conditioning system. Two electrically operated smoke dischargers are mounted either side of the turret.

#### Variants

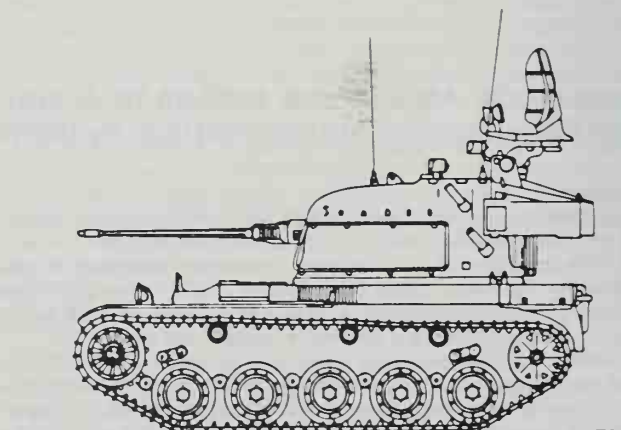
#### AMX-30 DCA

In the late 1960s an AMX-30 MBT chassis was fitted with the SAMM S401A turret as fitted on the AMX-13 DCA, but was not adopted by the French Army. In 1975 Saudi Arabia placed an order with Thomson-CSF for the development of the Shahine low altitude surface-to-air missile system, a further development of the Crotale but mounted on an AMX-30 MBT chassis rather than a 4  $\times$  4 wheeled vehicle. At the same time Saudi Arabia placed an order for 53 vehicles of an improved version of the AMX-30 DCA called the AMX-30 SA. The turret, designated the TG 230A, is a further development of the SAMM S401A and is armed with the same 30 mm weapons, each of which has 300 rounds of ammunition in the ready racks. In addition a further 900 rounds are carried inside the hull in reserve. Both the commander and gunner have a periscope for using the weapons in the ground-to-ground role and SAGEM sights with a magnification of  $\times 1$  and  $\times 6$  (12° field-of-view) respectively for anti-aircraft use. The SAGEM sights are used at a range of 3000 to 3500 m to identify the target.

The AMX-30 SA has the improved Thomson-CSF Oeul Vert (or Green Eye) D-band pulse Doppler radar with a maximum range of over 15 km for remote surveillance and over 7.5 km for close surveillance of pop-up targets. The radar can be used against targets between 0 and 3000 m altitudes with radial velocities from 30 to 300 m/s as well as hovering helicopters.



AMX-13 DCA twin 30 mm self-propelled anti-aircraft gun in travelling configuration with radar retracted (ECP Armées)



AMX-13 DCA twin 30 mm self-propelled anti-aircraft gun with radar erected





AMX-30 SA twin 30 mm self-propelled anti-aircraft gun with radar erected. This is the model in service with Saudi Arabia

## AMX-30 SABRE

The AMX-30S chassis has been fitted with the twin 30 mm SABRE turret developed from the TG 230A turret of the AMX-30 DCA. Details of SABRE, which never entered quantity production, were given in *Jane's Land-Based Air Defence 1990-91* pages 66/67.

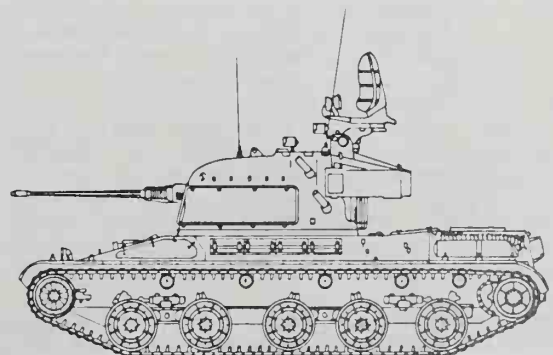
### SPECIFICATIONS (AMX-13 DCA)

CREW	3
COMBAT WEIGHT	17 200 kg
POWER-TO-WEIGHT RATIO	14.53 hp/t
GROUND PRESSURE	0.86 kg/cm <sup>2</sup>
LENGTH	5.4 m
WIDTH	2.5 m
HEIGHT	
with radar operating	3.8 m
with radar retracted	3 m
GROUND CLEARANCE	0.43 m
TRACK	2.159 m
TRACK WIDTH	350 mm
MAX ROAD SPEED	60 km/h
FUEL CAPACITY	415 l
MAX ROAD RANGE	300 km
FORDING	0.6 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	
forwards	0.65 m
reverse	0.45 m
TRENCH	1.7 m
ENGINE	SOFAM Model 8 Gxb 8-cylinder water-cooled petrol developing 250 hp at 3200 rpm manual with 5 forward and 1 reverse gears
TRANSMISSION	Cleveland type differential
STEERING	Ferodo single-disc
CLUTCH	torsion bar
SUSPENSION	24 V
ELECTRICAL SYSTEM	8 × 12 V
BATTERIES	2 × 30 mm cannon
MAIN ARMAMENT	2 × 2 smoke dischargers
SMOKE-LAYING EQUIPMENT	600
AMMUNITION	
GUN CONTROL EQUIPMENT	
turret power control	hydraulic/manual
by commander	yes
by gunner	yes
max rate power traverse	80°/s (120°/s acceleration)

max rate power elevation	45°/s
gun elevation/depression	+85°/-8°
turret traverse	360°
commander's fire control override	yes
ARMOUR	
hull front	15 mm at 40°
hull sides	20 mm
hull top	10 mm
hull floor	
front	20 mm
rear	10 mm
hull rear	15 mm
turret	15 to 20 mm

**Status:** AMX-13 DCA, production complete. In service only with the French Army (60). AMX-30 SA, production complete. In service only with Saudi Arabia (53).

**Prime contractor:** Although the chassis of the AMX-30 DCA was manufactured by GIAT Industries, prime contractor and systems integrator for the AMX-30 DCA systems supplied to Saudi Arabia was: Thomson-CSF, Division Systèmes Électroniques, 9 rue des Mathurins, BP 150, F-92223 Bagneux Cedex, France.  
Telephone: (1) 40 84 40 00  
Telex: THOM616780F



AMX-30 SA 30 mm self-propelled anti-aircraft gun with radar erected (not to 1/76th scale)

## Dassault Electronique VDAA Twin 20 mm Self-propelled Anti-aircraft Gun System

### Development Description

The VDAA (*Véhicule d'Auto-Défense Antiaérienne*) was developed by Renault Véhicules Industriels and Dassault Electronique as a private venture specifically for the export market. It consists of either the 4 × 4 or 6 × 6 version of the VAB fitted with a Dassault Electronique TA-20 twin 20 mm turret which can also be fitted with a Dassault Electronique RA-20S E-band 1 to 12 km range fully coherent pulse Doppler radar system. A typical VDAA unit will comprise two vehicles: a leader vehicle with the TA-20 turret and the RA-20S radar and a satellite vehicle with the TA-20 turret only. A crew of three, comprising the driver, vehicle commander and gunner is carried. This turret is also fitted to the Panhard M3 VDA twin 20 mm self-propelled anti-aircraft gun system which is fully described in the following entry. The VAB chassis can also be fitted with the MATRA SATCP MISTRAL SAM system which is covered in the *Self-Propelled Surface-to-Air Missile Systems* section.

### SPECIFICATIONS (6 × 6 version)

CONFIGURATION	6 × 6
CREW	3
COMBAT WEIGHT	14 200 kg
LENGTH	5.98 m
WIDTH	2.49 m
HEIGHT (to hull top)	2.06 m
GROUND CLEARANCE	
axles	0.4 m
hull	0.5 m
TRACK	2.035 m
WHEELBASE	1.5 m + 1.5 m
MAX SPEED	
road	92 km/h
water	7.5 km/h
MAX ROAD RANGE	1000 km
FORDING	amphibious
GRADIENT	50%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.4 m
TURNING RADIUS	9 m
ENGINE	MAN D 2356 HM72 6-cylinder in-line water-cooled diesel developing 235 hp at 2200 rpm



VDAA twin 20 mm self-propelled anti-aircraft gun system based on Renault VAB (6 × 6) chassis

TRANSMISSION	transfluid with 5 forward and 1 reverse gears
STEERING	recirculating ball, hydraulically assisted
TYRES	14.00 × 20
BRAKES	disc
SUSPENSION	independent (torsion bar and telescopic shock absorbers)
ARMAMENT	2 × 20 mm cannon

**Note:** From 1983 the MAN engine was replaced in production vehicles by the Renault VI MIDS 06.20.45 6-cylinder, in-line, water-cooled, turbocharged diesel developing 230 hp at 2200 rpm.

**Status:** Production as required. In service with Oman National Guard (total of nine systems; three with radar and six without).

**Manufacturer:** Dassault Electronique, 55 quai Marcel Dassault, F-92214 Saint-Cloud, France.  
Telephone: (1) 49 11 80 00  
Telex: 633 299 F

## Dassault Electronique M3 VDA Twin 20 mm Self-propelled Anti-aircraft Gun System

### Development

The M3 VDA (*Véhicule de Défense Antiaérienne*) was a joint development between Panhard and Dassault Electronique and consisted of a Panhard M3 APC fitted with a new turret. Major subcontractors are Hispano-Suiza (turret), Oerlikon (guns) and Galileo (sight).

Design work on the M3 VDA began in 1972 and the first prototype was completed in December 1973. Manufacturers' trials took place between January and March 1974 and qualification trials in May 1974. Production began in April 1975 and since then sales have been made to a number of countries. Early in 1991 Dassault Electronique stated that production of this system had ceased and it was no longer being marketed.

### Description

The hull of the M3 VDA is almost identical to that of the M3 APC and is of all-welded steel armour construction which provides the crew with protection from small-arms fire and shell splinters. The driver is seated at the very front and has a single-piece hatch that opens to the left with three integral periscopes. The engine is to his immediate rear. In either side of the hull is a door which opens to the front and there are two doors in the hull rear that open outwards. The only difference is that the M3 VDA has four hydraulically operated outriggers which are lowered to the ground before firing to provide a more stable firing platform. In an emergency the weapons can be fired without the outriggers in position at the lower rate of fire of 200 rds/min per gun.

The gunner is seated in the turret and the commander in the hull to the rear of the turret. The gunner has a single-piece hatch cover, six periscopes and the Galileo P56T sight which has a magnification of × 5 and a 12° field-of-view for engaging aircraft, a sight for engaging ground targets and a wiper and washer.

Main armament consists of two Hispano-Suiza 820 SL 20 mm cannon mounted externally on the rear of the turret. Reloading and cocking are carried out from inside the turret, and the empty cartridge cases and links are ejected externally. French M621 or M693 cannons can be fitted in place of the Hispano-Suiza 820 SL weapons if required. The gunner can select



M3 twin 20 mm VDA in firing position with outriggers deployed

single shots, bursts or full automatic, and the weapons have two cyclic rates of fire; 200 or 1000 rds/barrel/min. The gunner can select either left or right weapons, or both together. Each barrel is provided with 300 rounds of ready use ammunition.

The weapons have an elevation of +85°, depression of -5° and turret traverse of 360°. Gun elevation and turret traverse are hydraulic with an electric backup system and manual controls for emergency use. Maximum



effective altitude of the 20 mm cannon is 1500 m and maximum horizontal range is 2500 m. The full range of 20 mm ammunition can be fired including HE-I, HEI-T, APHE-I, APIC-T and practice.

A 7.5 mm or 7.62 mm machine gun with 200 rounds is provided for local protection and two electrically operated smoke dischargers are mounted either side of the lower part of the turret and fire forwards.

Mounted on the rear of the turret is a Dassault Electronique RA-20 1 to 8 km range fully coherent pulse Doppler radar which operates in the E-band and rotates at 40 rpm, carries out both surveillance and target acquisition (track while scan) and can track four targets simultaneously. The commander is provided with a radar implementation control, PPI, target assignment and acquisition controls, sound alarm that warns when a target has entered the surveillance area and a warning light that indicates the presence of a jammer. Once the commander has decided that the target is to be engaged the radar feeds the target bearing to the optical sight and the range and target speed to the computer. The gunner keeps the optical sight on the target with the aid of a joystick, the computer calculates the lead angle and when the target is in range firing begins.

Optional equipment for the M3 VDA includes an IFF system, laser rangefinder and a TV tracking system.

The M3 VDA can provide target information by radio to up to four other vehicles without radar. Radar-less vehicles can also be fitted with a satellisation device on the commander's console which allows the M3 VDA with radar to pass data directly to the vehicle. Vehicles without the radar system are delivered with all the mountings and cabling to enable the radar to be retrofitted.

The vehicles without the radar system have two POSs (*Postes Optiques de Surveillance*), one for the driver and one for the commander, each with a magnification of  $\times 1.5$  and a  $40^\circ$  field-of-view and covering an arc of  $190^\circ$ . When the vehicle is stationary both the commander and driver search for targets and as soon as one of them detects a target he lines up the sight with it and transfers the target to the turret, which automatically swings in azimuth onto it and the guns are simultaneously elevated onto the target. When the target is within range firing begins.

#### Variants

There are no variants other than those mentioned in the description. This turret has also been fitted on other chassis including the AMX VCI, VAB (6  $\times$  6), ERC (6  $\times$  6), SIBMAS (6  $\times$  6), Urutu (6  $\times$  6) and Steyr APC. Algeria has bought a quantity, known as TA-23, which uses Soviet 23 mm cannon in place of the 20 mm guns. It is not known on which vehicle Algeria has mounted the turrets.

To meet the requirements of the Egyptian Army, Dassault Electronique developed the Sinai twin 23 mm SPAAG on an M113A2 chassis, this uses a modified VDA type turret and full details are given under Egypt earlier in this section.

#### SPECIFICATIONS

CREW	3
CONFIGURATION	4 $\times$ 4
COMBAT WEIGHT	7200 kg
POWER-TO-WEIGHT RATIO	12.5 hp/t
LENGTH	4.45 m
WIDTH	2.4 m
HEIGHT (without radar)	2.995 m
GROUND CLEARANCE	0.35 m
TRACK	2.05 m
WHEELBASE	2.7 m



M3 VDA twin 20 mm SPAAG in travelling configuration

MAX ROAD SPEED	90 km/h
FUEL CAPACITY	165 l
MAX ROAD RANGE	1000 km
FORDING	amphibious
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.3 m
TRENCH	
with 1 channel	0.8 m
with 4 channels	3.1 m
TURNING RADIUS	5.25 m
ENGINE	Panhard Model 4 HD 4-cylinder air-cooled petrol developing 90 hp at 4700 rpm
TRANSMISSION	manual with 6 forward and 1 reverse gears
CLUTCH	centrifugal with electromagnetic control
SUSPENSION	independent, coil spring and hydro-pneumatic shock absorbers acting on suspension trailing arms of wheel mechanism
TYRES	11.00 $\times$ 16
BRAKES	
main	hydraulic, dual circuit
parking	handbrake operating on gearbox output shaft
ELECTRICAL SYSTEM	24 V
BATTERIES	2 $\times$ 12 V
ARMAMENT	
main	2 $\times$ 20 mm cannon
secondary	1 $\times$ 7.62 mm MG
SMOKE-LAYING EQUIPMENT	2 $\times$ 2 smoke dischargers
AMMUNITION	
main	600
secondary	200
GUN CONTROL EQUIPMENT	
turret power control	hydraulic/electric/manual
by commander	no
by gunner	yes
max rate power traverse	60°/s
max rate power elevation	90°/s
gun elevation/depression	+85°/-5°
turret traverse	360°
ARMOUR	
hull	8-12 mm
turret	8-10 mm

**Status:** Production complete. In service with the Ivory Coast (6), the United Arab Emirates (Abu Dhabi 42) and one unidentified country.

**Manufacturer:** Chassis: Société de Constructions Mécaniques Panhard et Levassor, 18 avenue d'Ivry, F-75621 Paris, Cedex 13, France.

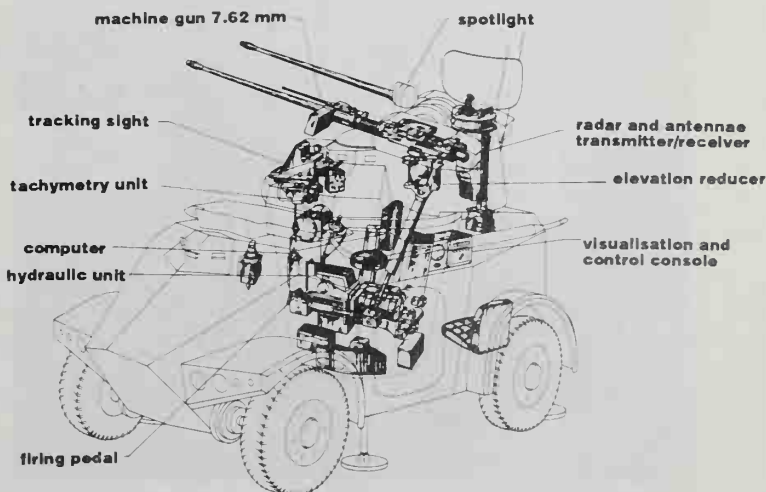
Telephone: (1) 49 11 80 00

Telex: 270 276 F

Turret integration: Dassault Electronique, 55 quai Marcel Dassault, F-92214 Saint-Cloud, France.

Telephone: (1) 46 02 50 00

Telex: 633 299 F



M3 VDA fitted with Dassault Electronique radar on turret rear (not to 1/76th scale)

## Panhard AML S530 Twin 20 mm Self-propelled Anti-aircraft Gun

### Development

This system was developed specifically for the export market and consists of a Panhard AML (4 × 4) light armoured car chassis fitted with the SAMM S530 twin 20 mm powered anti-aircraft turret. It was first shown at the Satory exhibition of military equipment in 1971.

A total of 12 systems were delivered to Venezuela in 1973 and these remain in service today.

SAMM and Panhard are no longer marketing this system.

### Description

The basic chassis is virtually identical to the standard AML, over 4800 of which have been built in France and under licence in South Africa by Sandock Austral.

The all-welded steel hull of the AML is divided into three compartments: driver's at the front; fighting in the centre and engine at the rear. The driver is seated at the front of the hull and is provided with a single-piece hatch cover that opens to the right with three integral periscopes. The central periscope can be replaced by an infra-red or image intensification periscope for night driving.

The all-welded steel armour turret is mounted in the centre of the hull and was designed and built by SAMM. The commander, who also operates the roof-mounted white light searchlight, sits on the left and the gunner on right. The commander has a single-piece hatch cover which opens to the rear while the gunner has a single-piece hatch cover that opens to the right.

Observation equipment consists of seven L794B periscopes; three for the gunner and four for the commander. Each of these has a vertical field-of-view of 27° and a horizontal field-of-view of 55° while the gunner has a roof-mounted M411 periscopic sight.

The M411 has a × 6 sight for engaging ground targets with a 10° field-of-view, an observation periscope with × 1 magnification, vertical field-of-view of 12°, horizontal field-of-view of 55° and a collimator. The latter has an adjustable light intensity reticle with image set to infinity, display lead for slow (100 m/s) and fast (200 m/s) dive down and horizontal flights and fire range estimation (1300 m).

The turret was also offered with another sighting system, type M251, for observation and engaging ground targets and with the L834-13 for anti-aircraft use.

Turret traverse and weapon elevation is under full power control with manual controls provided for emergency use. Turret traverse is 360° at a maximum speed of 80°/s while elevation is from -10 to +75° at a maximum speed of 40°/s.

Main armament comprises two GIAT Industries M621 20 mm cannon, each of which has 300 rounds of ammunition. The gunner can select either single shots, short bursts or full automatic with the cyclic rate of fire being 740 rds/barrel/min.

The firing switch is on the gunner's control handle although there is also an emergency foot pedal. Effective range in the anti-aircraft role is between 1500 and 2000 m.

French and US M56 types are included in the types of 20 mm ammunition fired. Among the French types used are the following: an HE tracer (muzzle velocity 990 m/s); an armour-piercing tracer which can penetrate 23 mm of armour at 0° at a range of 1000 m muzzle velocity (1000 m/s); an



*Panhard AML S530 twin 20 mm SPAAG from front with hatches closed and showing sand channels on front of hull*

HE (muzzle velocity 1026 m/s) and an incendiary (muzzle velocity 1026 m/s).

The gunner can also select either the left or right cannon and both weapons are normally used for air defence purposes. The empty cartridge cases and links are ejected from turret.

The system is clear weather only with no provision for off carriage fire control, although general target information such as range, altitude and bearing can be provided over the radio net.

Two electrically operated smoke dischargers are mounted either side of the turret towards the rear. Either side of the hull below the turret ring is a door. The left door, on which a spare wheel and tyre is mounted, opens to the rear while the right door opens to the front. The engine compartment which is at the rear of the hull has two access panels. The gearbox is crosswise and consists of two gearboxes in one (high and low), coupled on both sides of the bevel pinion.

The low-range box is for cross-country use and comprises two low gears, a top gear and one reverse gear. When it is in normal drive the four ratios of the high-range box command the four upper gears of the range: sixth, fifth, fourth and third. The high-range box is for normal road use and has three low gears and one overdrive. There are Panhard-type ball differentials in the gearbox and in each rear transfer box which automatically prevent gear slip. Drive is transmitted from the gearbox to two lateral transfer boxes via pinions to the rear wheels and via drive shafts that run along the inside of the hull to the front wheels.

The independent suspension at each wheel station consists of coil springs and hydro-pneumatic shock absorbers acting on the trailing arms of the wheel mechanism. The tyres are fitted with puncture-proof Hutchinson inner tubes.

Sand channels are carried across the hull front and when in position these enable the vehicle to cross ditches and other obstacles.

### Variants

The SAMM S530 turret was also offered for installation on many other tracked and wheeled armoured vehicles but the only other known installation, for trials purposes, was on the AMX-13 light tank.

The S530 A has an M411 sight with a magnification of × 1 for engaging aircraft, retractable sun filter and a × 6 magnification sight with a 10° field-of-view for engaging ground targets. The S530 F is the latest version and is



*Panhard AML S530 twin 20 mm SPAAG with turret traversed partly left and showing space for spare wheel and tyre on side door*





*Panhard ERC Sagaie (6 × 6) Kriss, a further development of the S530 with slightly different front and sides*

also known as the TAB 220. Four of these have been sold to Gabon and installed on the Panhard ERC Sagaie (6 × 6) chassis and full details of this are given in the entry for the French SANTAL self-propelled surface-to-air missile system. The S530 F has the M411 sight and a moving prism episcopic channel for observation with an elevation from  $-10^{\circ}$  to  $+70^{\circ}$ , a magnification of  $\times 1$ , a horizontal field-of-view of  $77^{\circ}$ , a vertical field-of-view of  $32^{\circ}$  plus seven observation periscopes. This turret can also be fitted with a Ferranti Mk 3 self-contained gyroscopic sight and receive target information from a vehicle with a radar system. Typically one radar vehicle would control six twin 20 mm systems. When fitted onto the Sagaie (6 × 6) armoured car the system is known as the Kriss.

#### SPECIFICATIONS

CREW	3
CONFIGURATION	4 × 4
COMBAT WEIGHT	5500 kg
POWER-TO-WEIGHT RATIO	16.36 hp/t
LENGTH GUNS FORWARD	3.90 m
LENGTH HULL	3.79 m
WIDTH	
overall	1.97 m
over hubs	1.925 m
HEIGHT	
overall	2.24 m
hull top	1.385 m
GROUND CLEARANCE	0.33 m
TRACK	1.62 m
WHEELBASE	2.5 m
MAX ROAD SPEED	
6th gear, high range	90 km/h
5th gear, high range	61 km/h
4th gear, high range	35 km/h
3rd gear, high range	18.8 km/h

3rd gear, low range	18.8 km/h
2nd gear, low range	9.3 km/h
1st gear, low range	4.5 km/h
reverse	5.5 km/h
FUEL CAPACITY	156 l
MAX ROAD RANGE	600 km (at 60 km/h)
FORDING	1.1 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.3 m
TRENCH	
with one channel	0.8 m
with four channels	3.1 m
TURNING RADIUS	6 m
ENGINE	Panhard Model 4HD 4-cylinder air-cooled diesel developing 90 hp at 4700 rpm (see note)
TRANSMISSION	manual with 6 forward and 1 reverse gears
CLUTCH	centrifugal with electromagnetic automatic control
SUSPENSION	independent spring and hydro-pneumatic shock absorbers acting on suspension trailing arms of wheel mechanism
TYRES	11.00 × 16
BRAKES	
main	hydraulic, dual circuit
parking	handbrake operating on gearbox output shaft
ELECTRICAL SYSTEM	24 V
BATTERIES	2 × 12 V
ARMAMENT	2 × 20 mm cannon
SMOKE DISCHARGERS	2 × 2
AMMUNITION	600 × 20 mm
GUN CONTROL EQUIPMENT	
turret power control	electrohydraulic/manual
turret traverse	360°
gun elevation/depression	$+75^{\circ}/-10^{\circ}$
GUN STABILISER	no
ARMOUR	
hull	8 mm (max)
turret	7 to 14 mm

**Status:** Production complete. No longer being marketed. In service with Venezuela (12). The Panhard ERC Sagaie (6 × 6) Kriss is in service with Gabon (4).

**Manufacturer:** Chassis: Société de Constructions Mécaniques Panhard et Levassor, 18 avenue d'Ivry, F-75621 Paris, Cedex 13, France.  
Telephone: (33) (1) 40 77 40 00  
Telex: 270 276 F

Turret: Société d'Applications des Machines Motrices, Chemin de Malmaison, F-91570 Bièvres, France.  
Telephone: (33) 69 41 80 88  
Telex: 933-1 69 41 15 72  
Fax: (33) 60 19 03 00

## INTERNATIONAL

### Krauss-Maffei/Oerlikon Contraves Gepard and CA 1 Twin 35 mm Self-propelled Anti-aircraft Gun Systems

#### Development

In 1965 a decision was taken to develop a new self-propelled anti-aircraft gun for the West German Army as a replacement for the clear weather M42, which would have an all-weather fire control system and be based on the chassis of the Leopard 1 MBT. In June 1966 a contract was placed for the development of a twin 30 mm vehicle which later became known as the Matador. Prime contractors for this were Rheinmetall (armament and turret), AEG-Telefunken (target tracking radar and computer), Siemens (search radar and IFF) and Krauss-Maffei/Porsche (chassis and power supply system).

At the same time a contract for two vehicles armed with twin 35 mm cannon was awarded to a consortium consisting of Oerlikon (armament and turret), Contraves (computer and systems integration), Siemens-Albis

(tracking radar), Hollandse Signaalapparaten (search radar) and Krauss-Maffei/Porsche (chassis and power supply system). These two prototypes were called the 5PFZ-A and were delivered in 1968.

Following comparative trials with the Matador and the 5PFZ-A a decision was taken in 1970 to concentrate further development on the twin 35 mm version developed in Switzerland. Before this decision an order had been placed for a further four twin 35 mm versions called the 5PFZ-B, which were delivered in 1971 and had their original Dutch search radar replaced by a German Siemens MPDR-12 radar with a Siemens MSR-400 IFF system. A pre-production batch of 12 vehicles was subsequently ordered and delivered by 1973. In September 1973 an order for 420 Gepards was placed for the German Army and the first production vehicles were delivered late in 1976; production was finally completed late in 1980. The first 195 vehicles were delivered as B2 versions and the remaining 225 as B2L which are fitted with a laser rangefinder of Siemens design and manufacture. Belgium ordered 55 vehicles which were delivered between 1977 and 1980.



*Gepard twin 35 mm self-propelled anti-aircraft gun system with surveillance radar erected and tracking radar retracted (Christopher F Foss)*

In 1969 the Dutch ordered a version with the same chassis and turret as the 5PFZ-B but fitted with Hollandse Signaalapparaten integrated Ka-band monopulse Doppler surveillance and tracking radar with moving target indication and a peak emission power output of 160 kW. This model was called the 5PFZ-C and was followed by five pre-production vehicles which were delivered in 1971/72. The Dutch subsequently ordered 95 production vehicles under the designation CA 1 which were delivered between 1977 and 1979. The Dutch Army designation for the vehicle is the Pantser Rups Tegen Luchtdoelen (PRTL).

#### Description

The all-welded steel hull of the Gepard is slightly longer than the Leopard 1 MBT's and has slightly thinner armour.

The driver is seated at the front of the hull on the right side and has a single-piece hatch cover that opens to the left of his position and three periscopes in front of him. To the left of the driver is the Daimler-Benz OM314 95 hp auxiliary power unit, for which the exhaust pipe runs along the left side of the hull to the rear.

The two-man all-welded steel turret is in the centre of the hull with the commander seated on the left and the gunner on the right. Over their position is a single-piece hatch cover that opens to the rear and periscopes arranged around it give all-round observation with the hatch closed.

In front of both the commander's and gunner's position is a fully stabilised panoramic telescope with a magnification of  $\times 1.5$  ( $50^\circ$  field-of-view) and  $\times 6$  ( $12.5^\circ$  field-of-view), each of which has a swing-in sun filter, screen washer and wiper, and a de-icing and de-misting heater. The sights can be automatically slaved to the tracking radar and therefore have an elevation of  $+85^\circ$ , a depression of  $-10^\circ$  and a total traverse of  $360^\circ$ . The sights are used for optical target acquisition, battlefield surveillance and the laying of the guns against ground targets. An optical target indicator mounted on the commander's panoramic telescope is operated by the commander standing in his open hatch.

The Gepard has a vehicle navigation system and the screen of the radar is always north oriented. Information from the radar system can be transmitted by radio in digital form and displayed on a similar monitor at

headquarters. The vehicle is also provided with an NBC system and four smoke dischargers are mounted on either side of the turret.

Mounted on the rear of the turret is the fully coherent pulse Doppler search radar, which operates in the E/F-bands and has a range of 15 km. It rotates at 60 rpm and provides continuous air space surveillance with an IFF capability. The radar can be operated when the vehicle is moving and when not required, it can be folded down behind the rear of the turret to reduce overall height. As soon as an aircraft appears on the scope the crew is alerted. The target is displayed in terms of azimuth, angle and range and is identified as friend or foe. If the aircraft is hostile, information is passed to the coherent Siemens-Albis pulse Doppler tracking radar mounted on the front of the turret which has a range of 15 km, operates in the Ku-band and when not in use can be traversed  $180^\circ$  so that the antenna is facing the front of the turret. The tracking radar tracks the target automatically in terms of azimuth, elevation and range. At the same time the search radar is still maintaining a search for other targets. The acquisition range of the tracking radar allows target acquisitions within an angle of about  $200^\circ$  without rotating the turret.

The analogue computer calculates the lead angles taking into account weather, continuously measured muzzle velocity and the cant of the vehicle. Wind speed and direction, ballistic air pressure and ballistic air temperatures are fed in manually once a day. The guns normally open fire when the aircraft is between 3000 and 4000 m away, with the rounds reaching the target at a range of 2000 to 3000 m. The duration of the burst is a function of the range with a normal burst consisting of 20 to 40 rounds.

Main armament consists of two Oerlikon-Contrares 35 mm KDA cannon with a cyclic rate of fire of 550 rds/barrel/min. The guns are mounted externally, one either side of the turret and the anti-aircraft ammunition is fed via fixed and moving chutes, which are hermetically sealed from the fighting compartment. Each cannon is provided with 310 rounds of anti-aircraft and 20 rounds of armour-piercing ammunition. The following types of ammunition can be fired:

AMMUNITION TYPE	HEI	HEI-T	SAPHEI-T	APDS-T	TP/TP-T
WEIGHT OF PROJECTILE	0.55 kg	0.535 kg	0.55 kg	0.294 kg	0.55 kg
WEIGHT OF PROPELLANT	0.33 kg	0.33 kg	0.33 kg	0.33 kg	0.33 kg
WEIGHT OF EXPLOSIVE	0.112 kg	0.098 kg	0.012 kg	n/app	n/app
WEIGHT OF COMPLETE ROUND	1.58 kg	1.565 kg	1.552 kg	1.46 kg	1.58 kg
MUZZLE VELOCITY	1175 m/s	1175 m/s	1175 m/s	1390 m/s	1175 m/s

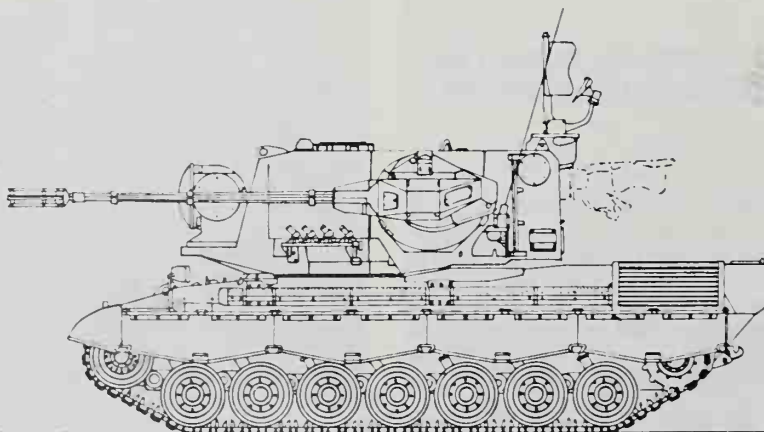
The computer is provided with an automatic unit which can check the total serviceability of the complete fire control system. If the main computer fails the crew can switch to an independent standby computer.

#### Gepard Upgrade

The German and Netherlands Armies have decided to upgrade their Gepard self-propelled air defence systems to extend their operational lives into the next century. In October 1989 a contract was concluded between the German Federal Office for Military Procurement and the prime contractor for the overall improvement programme, Krauss-Maffei of Munich.

Krauss-Maffei will be responsible for the chassis subsystem, while work relative to the turret subsystem has been subcontracted to Wegmann. A consortium led by Siemens has also been contracted to develop, manufacture and integrate the German and Netherlands fire control system.

The largest technological advance to be applied will be in the fire control system, incorporating a new digital fire control computer (control unit RSE) which will employ the latest microprocessors. The new computer, together with an improved fire control algorithm, will provide a shorter reaction time and higher hit probability even against accelerating and curving targets. Special interface cards are used to process the data of the tank's old



*Gepard twin 35 mm self-propelled anti-aircraft gun with surveillance radar erected. Dotted lines to rear of turret show radar's position when retracted*





Dutch version of Gepard, called CA 1, with tracking and surveillance radars by Hollandse Signaalapparaten, and six smoke dischargers each side of turret rather than four as on German and Belgian Army vehicles



German Army Gepard 35 mm self-propelled anti-aircraft gun with search radar antenna erected (Pierre Touzin)

systems and assemblies, which are still largely analogue. The data can then be called up by the fire control computer via a standard VME bus for further processing. In addition, the RSE establishes the link from the weapon system to the army air defence C<sup>2</sup> system.

The upgraded Gepard will also be provided with an optronic sensor so that the radar system will not have to be activated to seek, acquire and track targets, so enhancing ECM resistance. Instead of the aimer's periscope, a gyro-stabilised thermal imager will provide the operator with a video image and supply the RSE with target displacement values required for controlling the weapon system. A video tracker makes the optronic sensor track the target automatically.

A number of the German Gepard systems are already fitted with a laser rangefinder, and Siemens are currently supplying this equipment to the rest. The upgraded optronic sensor of the Netherlands version will employ an eye safe RAMAN laser.

The ergonomics of the Gepard will be significantly improved by the implementation of a new control and display concept with menu operation and a commander's decision making aid, revised console layouts with keyboard and graphic displays. In addition the German systems will also be fitted with a new cooling system.

In order to improve the availability of the weapon system, assemblies or subassemblies with a relatively high failure rate are being modified, and a sophisticated computer based fault detection and evaluation programme (BITE) is being developed to enable early detection of failures and initiate suitable action.

In addition to these improvements, the Gepard will be provided with a new self-defence system as well as higher performance ammunition.

Under present plans, the integration of the first upgraded fire control system is expected to start in 1991. Acceptance of the six German and two Netherlands trial models of the upgraded Gepard, including the upgraded

documentation, is scheduled for March 1993. This will be followed by the one year field trial and if these are successfully completed then full production will start in 1994 and run through the 1990s.

At present the Belgian Gepards are not to be upgraded.

**Note:** The Contraves AG twin 35 mm ATAК self-propelled anti-aircraft gun system is no longer being marketed.

#### SPECIFICATIONS

CREW	3
COMBAT WEIGHT	47 300 kg
UNLOADED WEIGHT	44 800 kg
POWER-TO-WEIGHT RATIO	17.54 hp/t
GROUND PRESSURE	0.95 kg/cm <sup>2</sup>
LENGTH GUNS FORWARD	7.73 m
LENGTH HULL	6.85 m
WIDTH	3.37 m
over tracks	3.25 m
HEIGHT	
radar up	4.03 m [3.7 m Dutch model]
to top of periscopes	3.01 m
FIRING HEIGHT	2.37 m
GROUND CLEARANCE	0.44 m
TRACK	2.7 m
TRACK WIDTH	550 mm
MAX ROAD SPEED	65 km/h
FUEL CAPACITY	985 l
MAX RANGE	
road	550 km
cross-country	400 km
FORDING	2.5 m
GRADIENT	60%
VERTICAL OBSTACLE	1.15 m
TRENCH	3 m
ENGINE	MTU MB 838 Ca M500, 10-cylinder multi-fuel developing 830 hp at 2200 rpm
TRANSMISSION	ZF 4 HP 250 planetary gear shift with hydraulic torque converter, 4 forward and 2 reverse gears regenerative double differential torsion bar
STEERING	24 V
SUSPENSION	2 × 35 mm cannon
ELECTRICAL SYSTEM	2 × 4 smoke dischargers [2 × 6 Dutch model]
ARMAMENT (main)	
SMOKE-LAYING EQUIPMENT	
AMMUNITION	
AA	620
AP	40
GUN CONTROL EQUIPMENT	
turret power control	hydraulic/manual
by commander	yes
by gunner	yes
turret traverse	360°
gun elevation/depression	+85°/-10°
max rate power traverse	90°/s
max rate power elevation	45°/s



Gepard twin 35 mm self-propelled anti-aircraft system of the Belgian Army with both radars in travelling position (C R Zwart)

**Status:** Production complete. In service with:

Country	Quantity	User	Comment
Belgium	55	army	delivered 1977/1980
Germany	420	army	delivered 1976/1980
Netherlands	95	army	delivered 1977/1979

**Manufacturer:** Krauss-Maffei, Wehrtechnik GmbH, Krauss-Maffei Strasse 2, D-8000 Munich 50, Federal Republic of Germany assembled the complete Gepard and CA 1. Prime contractor is Contraves AG, Schaffhauserstrasse 580, CH-8052, Zürich, Switzerland.  
Telephone: (01) 306 2211  
Telex: 823 402

## Hotspur/Rheinmetall Twin 20 mm Mobile Gun Platform

### Development

The twin 20 mm mobile gun platform was developed as a private venture between Hotspur Armoured Products of the United Kingdom and Rheinmetall GmbH of Germany.

It essentially consists of a modified version of the Hotspur One-Fifty 6 x 6 drive conversion of the well known Land Rover chassis, with the Rheinmetall twin 20 mm air defence system mounted on the rear. The latter is normally towed behind a truck but by installing it on the 6 x 6 chassis it has greater cross-country mobility and can be brought into action much more quickly.

### Description

The layout of the Hotspur mobile gun-platform is conventional, with the engine at the front, driver and gunner in the centre and the platform with the twin 20 mm cannon at the rear. The base chassis incorporates a driver's cab which is manufactured from aluminium and hinged so that it can be folded down and protect the driver's compartment, instrument panel and seats when the system is deployed in the firing position. Attached to the driver's cab is an 'in-transit' muzzle protection and branch deflection bar which is hinged and folded down with the vehicle cab when in the firing position.

The gun platform is fitted with a four pod automatic self-levelling hydraulic stabilising system which is operated automatically from the driver's position. The automatic system can be overridden by manual operation from the controls fitted at the rear of the gun platform, if required.

Additional features of the mobile gun platform include the capacity for carrying extra ammunition with locker and tool kit space being provided. A collapsible frame can be fitted to a canvas cover or camouflage net.



*Hotspur/Rheinmetall twin 20 mm mobile gun platform in firing position with outriggers deployed and cab in travelling configuration*

### SPECIFICATIONS

CREW	2
CONFIGURATION	6 x 6
GROSS WEIGHT	5350 kg
POWER-TO-WEIGHT RATIO	25 bhp/t
LENGTH	5.86 m
WIDTH	1.84 m
HEIGHT (travelling position)	2.5 m
GROUND CLEARANCE	0.21 m
TRACK	1.486 m
WHEELBASE	3.81 m
ANGLE OF APPROACH/DEPARTURE	35°/29°
MAX ROAD SPEED	95 km/h
FUEL CAPACITY	85 + 68 l
MAX RANGE	300 km + 230 km
TURNING RADIUS	8.6 m
ENGINE	V8, petrol 3.5 l, water-cooled, developing 134 bhp at 4000 rpm manual, 5 forward, 1 reverse
TRANSMISSION	2 speed
TRANSFER BOX	single dry plate, hydraulic
CLUTCH	power assisted, worm and roller
STEERING	
SUSPENSION	
front	dual rate coil springs, worm and roller dual rate coil springs, live beam axle double acting hydraulic dampers
mid and rear	dual frame live rear axle, dual rate coil springs, double acting hydraulic dampers
BRAKES	dual circuit
front	hydraulic servo-assisted disc
mid and rear	hydraulic servo-assisted drum
TYRES	7.50 x 16
NUMBER OF TYRES	6 + 1
ELECTRICAL SYSTEM	12 V split charge
BATTERIES	2 x 50 Ah

**Status:** Development complete. Ready for production.

**Manufacturers:** Hotspur Armoured Products, Division of Penman Engineering Limited, Heathhall, Dumfries DG1 3NY. UK.  
Telephone: (0387) 52784  
Telex: 779771  
Fax: (0387) 52784

Rheinmetall GmbH, Ulmenstrasse 125, D-4000 Dusseldorf, Federal Republic of Germany.  
Telephone: (0211) 44701  
Telex: 85833-0  
Fax: (0211) 483290

## Oerlikon-Breda 25 mm Gatling Weapon System (GWS)

### Development

In 1989, a team consisting of Oerlikon-Contraves of Switzerland and Breda of Italy announced that they were developing, as a private venture, a new 25 mm Gatling Weapon System (GWS) which is characterised by its extremely high rate of fire and its use of high performance Oerlikon-Contraves KBB ammunition.

The 25 mm Gatling Weapon System is being developed for the 1990s when shipborne and ground-based defence systems will be faced by improved missiles that are programmed to be able to execute complex manoeuvres, to be able to weave, close at supersonic speeds and combine in saturation attacks.

The two key applications of this system are ground-based anti-missile weapon systems and anti-seaskimmer weapon systems. The first application of the GWS is the twin Gatling naval mount called Barrage. This has a total

rate of fire of 10 000 rds/min and forms the gun module of the Myriad anti-missile system.

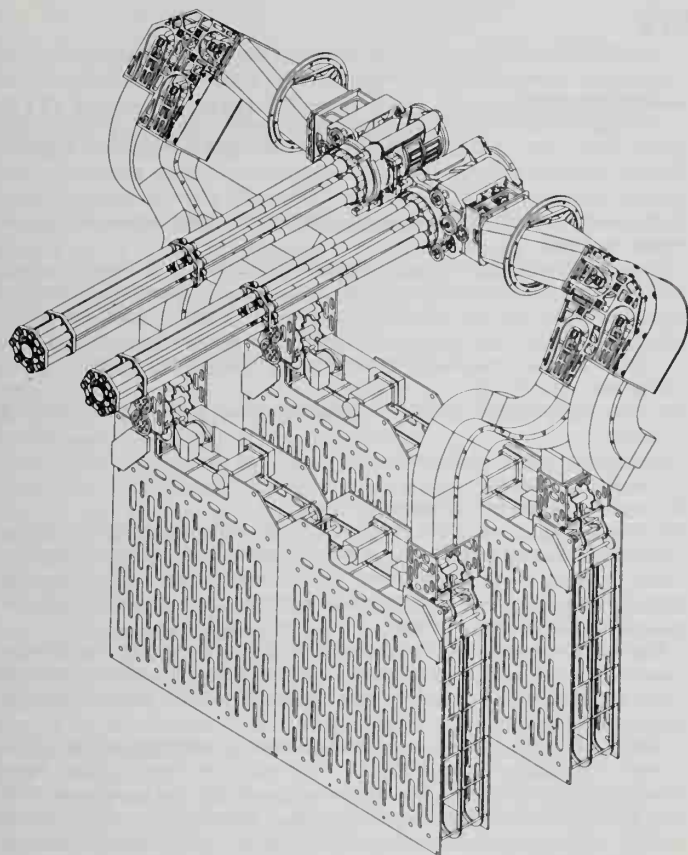
Responsibility for the Myriad programme is divided as follows:

- System engineering is assigned to Alenia and Elsas
- Tracking and sensors are assigned to Alenia with the participation of Contraves for specific components
- Fire control is the responsibility of Elsas with the participation of Contraves for specific components
- Responsibility for the mounting is assigned to Breda, installing twin Breda-Oerlikon 25 mm KBD Gatlings
- Ammunition is in current production by Oerlikon-Contraves.

Other potential applications being studied include towed Gatling air defence guns, a Gatling air defence tank as the formation leader in a group of towed Gatling air defence weapons and a Gatling air defence tank with optional 90° elevation capability.

By early 1991 the 25 mm KBD Oerlikon-Breda Gatling cannon had already been test fired at a cyclic rate of fire of 5000 rds/min. Two 25 mm KBD Oerlikon-Breda Gatling cannon are now being integrated into a mount





*Isometrical view of 25 mm Oerlikon-Breda Gatling weapon system showing two weapons and ammunition feed system*

for trials which are due to take place in early 1993. The first application of this system is naval and the first complete system, including the fire control system, is expected to be ready for shore trials from late 1992/early 1993.

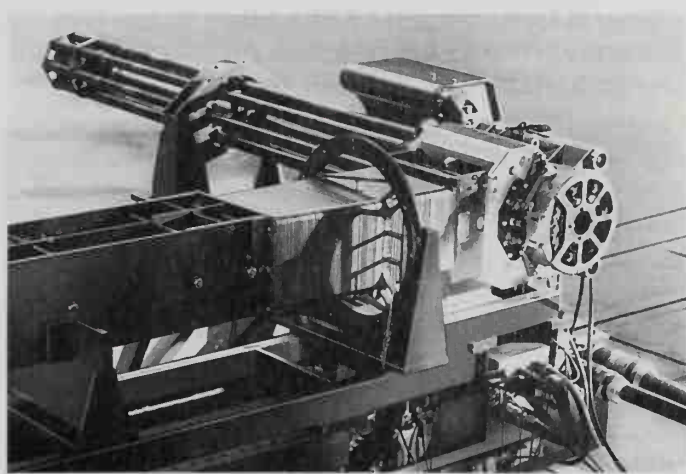
A typical Myriad anti-missile system would consist of the twin 25 mm KBD Oerlikon-Breda Gatling cannon with a total of 2000 rounds of ready use ammunition, Elsas computerised fire control system, Alenia Ku-band monopulse acquisition and tracking radar and Contraves W-band monopulse radar for accurate close range tracking.

#### Description

According to Oerlikon-Contraves and Breda, dealing with the threat of the 1990s requires a cannon system with a very high rate of fire that is capable of firing a new generation of high velocity ammunition.



*Barrage mounting showing twin 25 mm Gatling cannon*



*25 mm KBD Oerlikon-Breda Gatling cannon during trials*

The 25 mm Gatling Weapon System has a KBD 7-barrel weapon which is capable of firing 25 mm KBB ammunition at a cyclic rate of fire of 5000 rds/min. The KBB ammunition, especially the more recent AMDS (Anti-Missile Discarding Sabot) version, has a very low aerodynamic drag and this, combined with its higher muzzle velocity, reduces the flight time of the projectile and therefore the prediction error.

The penetrator used in the AMDS is a spin-stabilised tungsten alloy rod designed to pierce heterogeneous multi-layer armour without breaking up during penetration.

The KBD Gatling cannon can be optionally fitted with a hangfire safety mechanism which, even at the very high rates of fire, eliminates the danger of a round being fired from an unlocked breech-block.

Two types of ammunition of the KBB range can be stored ready for use in the magazines. The dual feed system feeds one of the two types of linkless ammunition at a time and is equipped for redundant mode operation. The linkless ammunition system has the advantage of increased operating safety and reliability as well as optimising ammunition packing density.

The system is microprocessor-controlled with external hydraulic or electric power drive. The manufacturers claim that its design is simple with high reliability and it has high redundancy and availability with independent subassemblies.

The empty cartridge cases are returned either to a separate spent case container or to the ammunition magazine. This improves the balance of the weapon system as well as solving problems associated with cartridge case ejection.

#### SPECIFICATIONS (Weapon)

CALIBRE	25 mm KBD
NUMBER OF BARRELS	7
RATE OF FIRE	5000 rpm
DISPERSION (50%)	1%
NUMBER OF AMMUNITION MAGAZINES AND AMMUNITION FEEDS	2
FIRST ROUND SWITCH-OVER	2 s
AMMUNITION MAGAZINE CAPACITY	500 rounds
WEIGHT OF 2 × 500 ROUNDS	650 kg
POWER SOURCE	about 50 kW
WEIGHT OF TOTAL WEAPON SYSTEM WITH 1000 ROUNDS	1600 kg
MUZZLE VELOCITY	
APDS-T	1285 m/s
AMDS	1270 m/s

**Status:** Under development.

**Manufacturers:** Oerlikon-Contraves Limited, CH-8052 Zurich, Switzerland.  
Telephone: (01) 306 22 11  
Telex: 823 402 coz ch  
Fax: (01) 301 34 66

Breda Meccanica Bresciana SpA, 2 Via Lunga, I-25128 Brescia, Italy.  
Telephone: (030) 31911  
Telex: 300056 BREDAR I

## General Dynamics/RAFAEL High Value Site Defense (HVSD)/Air Defence Advanced Mobile System (ADAMS)

### Development

The Air Defense Systems Division of General Dynamics of the United States has teamed with RAFAEL of Israel to develop a new point air defence system called the High Value Site Defense (HVSD)/Air Defence Advanced Mobile System (ADAMS). This is a further development of the original gun-only HVSD covered in *Jane's Land-Based Air Defence 1991-92* page 99.

The private venture system, first announced in 1990 and shown in full scale mock-up form at the Paris Air Display in 1991, is based on the mature 20 mm Phalanx Close-In Weapons System (CIWS) of the United States Navy (of which over 800 have been built) and RAFAEL's Barak-1 vertically launched missile covered in more detail in the next section.

According to the team members, the combination of the missile and gun into a single weapon system provides a lethal protective barrier for anything deemed of high enough value to ensure its survival.

As the key parts of the system are already in production, the first production systems could be delivered within 19 months of a firm order being placed.

In 1991 this system was proposed to Thailand with RAFAEL being the prime contractor and General Dynamics the main subcontractor. RAFAEL would be responsible for the launcher and missiles, Israel Aircraft Industries/TADIRAN for the control, communication and display unit (CCDU), Israel Aircraft Industries for the Launch Control Unit (LCU) with General Dynamics supplying the 20 mm Phalanx fire unit.

Other elements include the generator and the electrical and environmental control cabinets. For the Thai proposal, which was mounted on a 6 x 6 truck chassis, the other elements were mounted to the immediate rear of the cab.

### Description

The system consists of a cross-country vehicle, for example 6 x 6 or 8 x 8, with a radar-servo unit which retains the 20 mm Phalanx CIWS mounted on the chassis rear is a pod of 12 vertically launched Barak-1 missiles. One advantage of this is turret slewing is avoided which contributes to a very short reaction time and quicker target engagement.

The tracking radar of the Phalanx has been redesigned and the search radar relocated to provide search-while-track capability. The tracking radar would guide both the missile and the 20 mm cannon. Both the surveillance and tracking radars operate in the Ku-band and when the system is moving it will still be able to use its search radar but would come to a halt to engage targets.

The fire control system has been fitted with a new computer, including software, that would advise the operator as to which weapon (the 20 mm cannon or the Barak-1 missile) to use to engage a particular target.

The HVSD/ADAMS is a completely autonomous system and performs automatic detection, designation, acquisition, missile/gun mode selection, launching of missile or opening of gun fire and kill assessment.

The Barak-1 would be used to engage longer range targets out to a maximum of 12 km and minimum range of 500 m, while the 20 mm Gatling cannon would cover the gap from 100 m out to 2000 m.

The CCDU would be mounted in the cab of the vehicle or deployed up to 100 m away from it. The FLIR sensor could be added for day/night adverse weather operation.

A single HVSD/ADAMS fire unit would be able to defend an area from 500 m out to 12 km, but for maximum effectiveness it is suggested that two or three systems be deployed together. Maximum missile intercept range against helicopters is 12 km, aircraft 10 km and against missiles 8 km. Radar search and detection range is approximately 20 km with an acquisition range of 14 km.

Each HVSD/ADAMS has a potential of 19 ready kills, 12 from missiles and 7 from the gun system; when engaging missiles more than 7 kills can be achieved on aircraft, helicopters and RPVs. A total of 1550 rounds of 20 mm ammunition and 12 Barak-1 missiles are carried ready for use.

Typical protected assets of the system can be summarised as:

- (1) Airfields and aircraft
- (2) Troop concentration points, logistical convoys and armour assembly points
- (3) Command and control centres
- (4) Radar installations
- (5) Logistic centres and ammunition areas
- (6) Civil centres, government centres, factories and transportation assets.

The system is effective against smart bombs, anti-radiation missiles, cruise missiles, stand-off weapons, aircraft, helicopters, RPVs and glide bombs. According to the team members it will also provide limited defence against tactical ballistic missiles.

The above are the primary threats, but in addition the system can also be used for ground support in the direct fire role where the 20 mm cannon would be highly effective against light armoured and soft-skinned vehicles as well as troops.

The HVSD uses an active radar for an all-weather, autonomously operated system with accuracy improving as the threat gets nearer. It has been designed with the primary mission being to engage highly accurate and very fast missile threats in a rapidly changing scenario. The HVSD/ADAM system, less truck, is fully transportable by a C-130 Hercules tactical transport aircraft and when deployed in the firing position is normally stabilised by four outriggers deployed two either side. The system can also be integrated into an existing air defence system, gun battery or search radar using information from other sensors. It can also operate netted to other HVSD systems to form an air defence network.

**Status:** Private venture proposal. Full scale mock-up completed.

**Manufacturers:** RAFAEL, PO Box 2082, Haifa, Israel.

Telephone: 972 4 794714

Telex: 471508 VERED IL

Fax: 972 4 794653

General Dynamics, Air Defense Systems Division, PO Box 50800, Ontario, California 91761-1085, USA.

Telephone: (714) 945 1085

Fax: (714) 945 7890



Full scale mock-up of the HVSD system on a Mercedes-Benz truck chassis with outriggers deployed in position



Scale model of HVSD system on an 8 x 8 all-terrain vehicle with outriggers deployed in position



## ITALY

## OTO Melara Quad 25 mm Self-propelled Anti-aircraft Gun System (SIDAM 25)

### Development

The Quad 25 mm self-propelled anti-aircraft gun system, also known as the SIDAM 25, is a joint development between the Italian Army and OTO Melara with the assistance of a number of other Italian manufacturers, to meet an Italian Army requirement for this type of system.

Technical and operational evaluations of the two prototype systems commenced in 1983 with the final tests being carried out in 1986. Production of the turret systems commenced at OTO Melara's La Spezia facility in 1988 with first production systems completed in 1989. The original Italian Army requirement was for a total of 350 SIDAM 25 systems, but this was subsequently reduced to 280. By early 1991 the first two production batches of 35 and 40 vehicles had been completed and work on the third batch was underway. The SIDAM 25 is mounted on an upgraded M113 series APC which is used in large numbers by the Italian Army. To take account of the increased weight of the complete system, which is around 14 500 kg combat loaded, the M113 has been upgraded to the improved M113A2 configuration.

The SIDAM 25 turret system can be easily fitted on many other types of armoured vehicle, both tracked and wheeled, which include the Pegaso BMR-3560, Brazilian ENGESA EE-11 Urutu (6×6) APC, OTO Melara C13 APC and the VCC 80 IFV which is being developed by OTO Melara under contract to the Italian Army. Other major subcontractors to OTO Melara include Officine Galileo, Military Systems Division for the MADIS primary stabilised sighting system and Oerlikon-Italiana for the four 25 mm KBA cannons.

The M113 chassis is modified by Astra with the internal fuel tank being removed and replaced by two fuel tanks mounted one either side of the rear power operated ramp, installation of the more powerful Detroit Diesel 6V-53T engine developing 265 hp coupled to the existing TX-100 fully automatic transmission, fitting a reverse flow cooling system and modifying the suspension to allow for a gross vehicle weight of up to 15 t.

### Description

The overall layout of the chassis is almost identical to the basic M113 series armoured personnel carrier with the driver being seated at the front left and provided with a single-piece hatch cover and the powerpack to his right. The turret is mounted on the roof just to the centre of the vehicle with the power operated ramp being retained at the rear. The suspension either side consists of five rubber tyred road wheels, drive sprocket at the front and idler at the rear. There are no track return rollers and the upper part of the suspension is covered by a rubber skirt.

To the rear of the driver on the left side of the hull is the auxiliary power unit while on the right side of the hull are the fire control computer, TV tracker electronics, stable element, power supply unit, radio sets and finally the gunner's console.

The one-man all-welded aluminium alloy turret has four externally mounted Oerlikon-Italiana 25 mm KBA cannon. The turret is fitted with a day clear weather and low light level TV camera sighting system capable of tracking



OTO Melara Quad 25 mm SPAAG system SIDAM 25

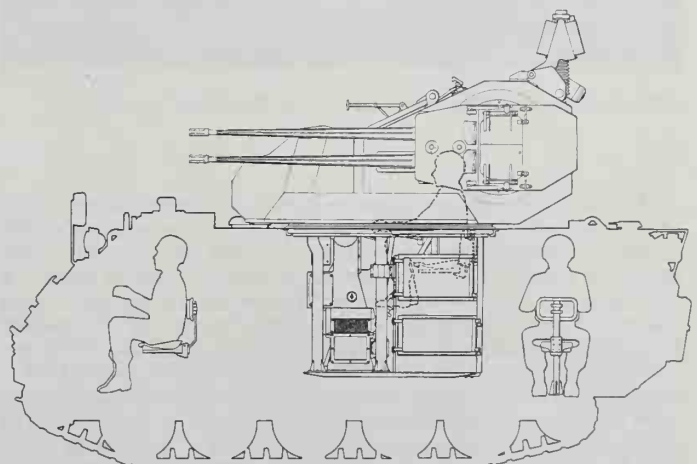
targets automatically. The fire control system utilises the Officine Galileo sighting equipment and gun electrohydraulic servo-system, a Selenia laser rangefinder, FIAR TV components and displays and an ITALTEL IFF system. A laser rangefinder, connected to a digital computer, provides the fire control data. The system has, however, no all-weather capability. The fire control system is controlled by two operators, with the commander being seated in the turret and the gunner in the vehicle. An IFF subsystem is also installed. An electronic tracking unit connected to the optronic sight performs the angular tracking of the target. Direct target detection and acquisition can be carried out by the commander in the turret by sight or via an optical sight. From the commander's acquisition, the target is assigned to the gunner who performs automatic tracking or manual tracking using a joystick. As an accurate stabilisation device is installed, all of the operations, with the exception of firing, can be carried out while the vehicle is moving. Target designation from an external source can also be accepted through a digital data link.

For this purpose the system is furnished with the threat calculator module which provides the operators with the following main information: First, threat priorities of each detected target (up to 10) are displayed on the monitors by means of a histogram. Second, engagement priority order is shown.

Extensive and successful integration tests have been carried out with the OTOMATIC (covered in the following entry) as a search and early warning system as well as other radar systems such as the Contraves LPD-20.



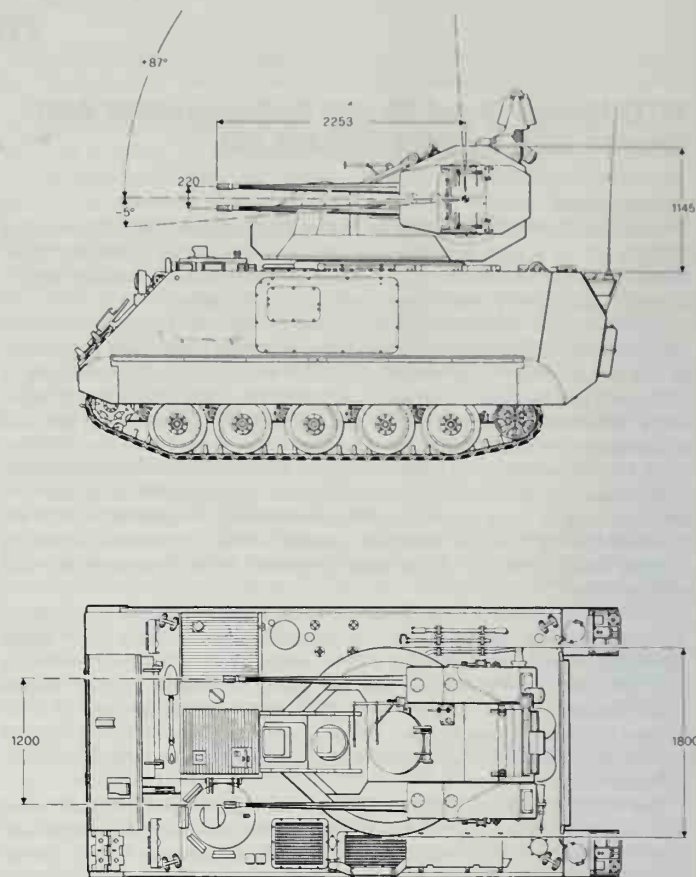
Melara Quad 25 mm SPAAG on M113A2 APC chassis



M113A2 armoured personnel carrier with SIDAM 25 turret, showing crew positions (not to 1/76th scale)



Close up of gunner's position in rear of SIDAM 25 SPAAG

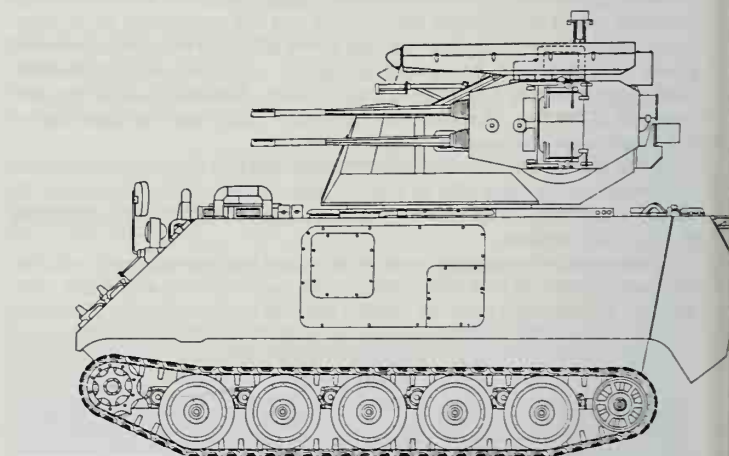


Top and side drawings of OTO Melara Quad 25 mm SPAAG system SIDAM 25 (not to 1/76th scale)



OTO Melara Quad 25 mm turret on Spanish BMR-3560 (6 x 6) APC

For all-weather and night operations a video-compatible thermal imager unit can be connected to the optronic sight for use in haze and smoke conditions together with a passive IR night and day sight. An inertial navigation system for improved attitude sensing may also be fitted. The practical rate of fire of the four guns is 2400 rpm, with the 640 HEI-T ready use rounds carried providing sufficient ammunition for eight two-second bursts or full automatic fire. A further 30 APDS-T ready use rounds are carried for ground defence. The maximum range of the guns is 2500 m although their effective range is 2000 m. The maximum traverse rate of the turret is 120°/s, and the maximum elevation rate 100°/s. The guns can be elevated to +87° and depressed to -5°. The mode of fire is either single shot, 15- or 25-round bursts or continuous fire. Two of the guns have a dual feed arrangement for firing both the APDS-T and HEI-T rounds. Other round types that can be fired are SAPHEI-T, TP-T, and APP-T (the last two for practice).



OTO Melara SIDAM 25 air defence system with three MATRA Mistral SAMs mounted above each bank of two 25 mm cannon

### SIDAM 25 with SAM

OTO Melara has completed studies of a SIDAM 25 system fitted with two packs of three MATRA Mistral fire-and-forget missiles that are already in volume production and selected by over 10 countries.

The 25 mm cannon would be used to engage close-in targets with the Mistral missiles being used to engage targets at longer ranges.

The Gulf War of 1991 demonstrated that air defence systems relying on radar for surveillance and tracking are highly vulnerable to a variety of defence suppression methods including anti-radiation missiles and electronic jamming.

The fire control system of the SIDAM 25 includes an automatic electro-optical TV tracking system that cannot be jammed.

This can be integrated with other search sensors via a data link that can accept data related to a number of targets. The automatic threat evaluation system indicates which target is the most dangerous as well as that most likely to be effectively engaged.



## SPECIFICATIONS

CHASSIS TYPE	VCC-1	C13	VCC-80	BMR
TYPE	tracked	tracked	tracked	6 × 6
COMBAT WEIGHT	15 100 kg	16 500 kg	20 000 kg	16 300 kg
LENGTH	5.041 m	5.65 m	6.705 m	6.15 m
WIDTH	2.686 m	2.71 m	2.98 m	2.50 m
HEIGHT (hull top)	1.828 m	1.72 m	1.75 m	2.00 m
GROUND CLEARANCE	0.406 m	0.40 m	0.40 m	0.40 m
MAX ROAD SPEED	64.4 km/h	70 km/h	70 km/h	100 km/h
RANGE	550 km	500 km	600 km	850 km
GRADIENT	60%	60%	60%	40%
SIDE SLOPE	30%	30%	40%	30%
VERTICAL OBSTACLE	0.61 m	0.7 m	0.85 m	0.6 m

**Status:** In production for Italian Army with first vehicles delivered in 1989. Has also been installed, for trials purposes, on the Spanish BMR-3560 (6 × 6) armoured personnel carrier chassis.

**Manufacturer:** OTO Melara SpA, via Valdilocchi 15, I-19100 La Spezia, Italy.

Telephone: (39 187) 581111

Telex: 270368 211101 OTO I

Fax: (39 187) 582669

## OTO Melara 76 mm Self-propelled OTOMATIC Air Defence Tank

### Development

The OTOMATIC 76 mm AA tank has been developed by OTO Melara as a mobile armoured anti-aircraft system for operation in forward areas to provide protection against attacks from helicopters and low-flying aircraft and by lightly armoured mobile ground forces. It will be capable of engaging helicopters at 6000 m before they release their ATGWs, aircraft at 4000 m and AFVs at 1500 m. Normally a five-round burst would be used against a helicopter.

The other operational requirements issued for the OTO 76 mm AA tank are all-weather operational capability, data link interface for external target acquisition and/or designation and the autonomous search capability. The prototype was shown in public for the first time at the 1987 Paris Air Show.

The second prototype was shown and operated (without the laser rangefinder for safety reasons) during the 1988 Farnborough Air Show.

By September 1988 the first prototype had had its search radar installed and carried out search and tracking tests against helicopters through to late 1988. It then went to an Italian Air Force base where it was able to carry out tracking trials against both aircraft and helicopters. In the second half of 1989 the OTOMATIC went to Sardinia for tests including range firing against aerial targets.

In the Spring of 1991, the Italian Army and Air Force started a year long evaluation of the OTOMATIC 76 mm turret installed on a modified Leopard 1 MBT chassis of the Italian Army with the actual chassis conversion being carried out and funded by OTO Melara. Modifications to the chassis included the installation of an auxiliary power unit in the hull front on the left side with the NBC system now in the tight sponson, the filters of which can be changed from the outside of the vehicle.

The batteries have been moved to the rear of the vehicle and are now outside the crew compartment. The heating system has been removed as the turret has an air-conditioning system.

The Leopard 1 engine and its heating system have been retained but the torsion bars of the vehicle have been modified and new shock absorbers installed since the vehicles combat weight is now 47 t compared to the 40 t for a standard Leopard 1 MBT.

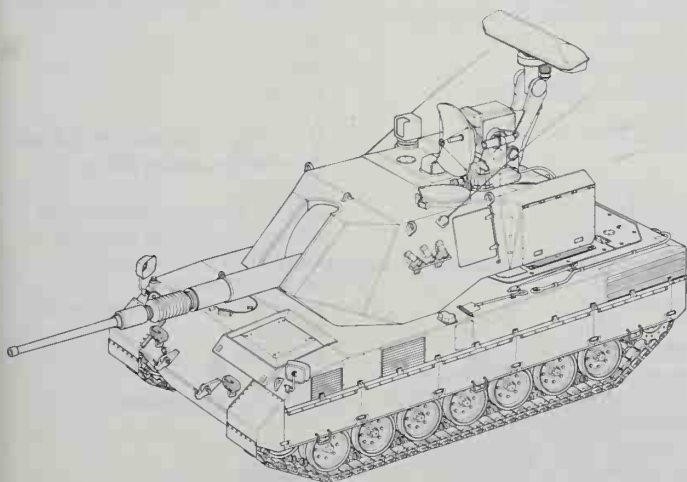
System trials started with surveillance and tracking against a variety of fixed- and rotary-wing aircraft with the former including F-104 Starfighters and will culminate in live firing trials against RPV targets in Sardinia.

### Description

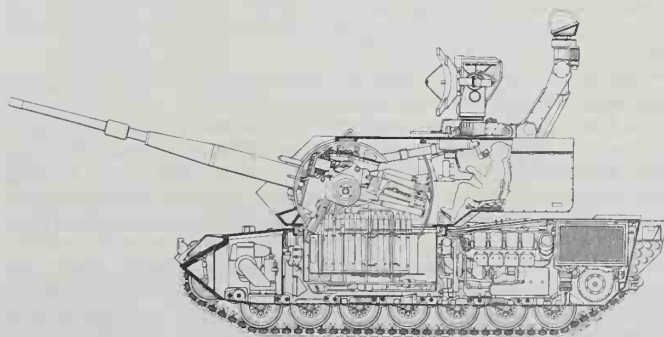
The OTOMATIC is basically a tank with modifications for the installation of the auxiliary power unit. Depending on the chassis, the driver is seated front right with the APU to his left, the turret in the centre and the engine and transmission at the rear. The all-welded steel turret has the loader on the left and the commander and gunner on the right. There is an entry door in either side of the turret and a circular hatch cover above the commander's and gunner's positions.

The turret is traversable through 360° and is made of all-welded steel armour which is sloped for maximum ballistic protection, it is controlled in traverse and elevation by an electrohydraulic servo system that provides a high turret slew rate and stability. The main armament is a 76 mm 62-calibre automatic gun with a vertical sliding breech-block and mechanical firing. The 62-calibre gun is derived from the 76 mm OTO Super Rapid naval gun with the maximum cyclic rate of fire per minute increased to 120 rounds. The gun has a maximum range of 16 km and is effective in the anti-aircraft mode out to 6000 m. The ammunition used includes the PFF prefragmented 12.2 kg anti-aircraft round with proximity fuze and the MOM multi-role 12.25 kg round with VT, PD and time delay fuzing. A 9.1 kg total weight APFSDS round has been developed for engaging ground targets. This will penetrate 150 mm of armour at 60° NATO incidence at a range of 2000 m. For the future OTO Melara will integrate into the system the 76 mm course-correction shell that it is developing with British Aerospace. Naval firing trials of the 76 mm course-corrected shell are expected to start late in 1991/early 1992.

A total of 90 rounds of ammunition are carried, 64 in the turret, of which 29 are in the gun's feeding and loading systems, and a further 26 in the hull. The hydraulically operated gun feeding and loading mechanisms allow ammunition loading at all gun elevations from -5 to +60°. Bursts of three to five rounds are normally fired. The gun is also independently stabilised to counter vehicle movement. The fire control equipment includes an optical sight system utilising a low light level TV camera, a TV tracker and a Nd:YAG laser rangefinder for use in both air and ground defence. A new all-weather fire control system has been developed which includes a search radar, IFF system, a tracking radar with coaxial TV camera and a secondary optical fire control unit for passive mode of operation and engaging ground targets. The search radar is an all solid-state fully coherent, pulse Doppler and pulse compression, MTI processing, agility frequency system, operating in the S-band with a dedicated channel or helicopter recognition. The tracking radar is a monopulse configuration, coherent on receive, pulse Doppler system operating in the Ka-band with clutter suppression (high improvement factor) and is claimed to be very accurate. The tracking antenna has a maximum elevation of +84° and a depression of -6° 30'. The maximum detection and tracking ranges of the two radars are around 15 and 14 km respectively. At least eight targets may be tracked simultaneously. The target is detected and acquired by the vehicle commander and target tracking is automatic, although manual



OTO Melara 76 mm OTOMATIC air defence tank on Palmaria SPG chassis (not to 1/76th scale)



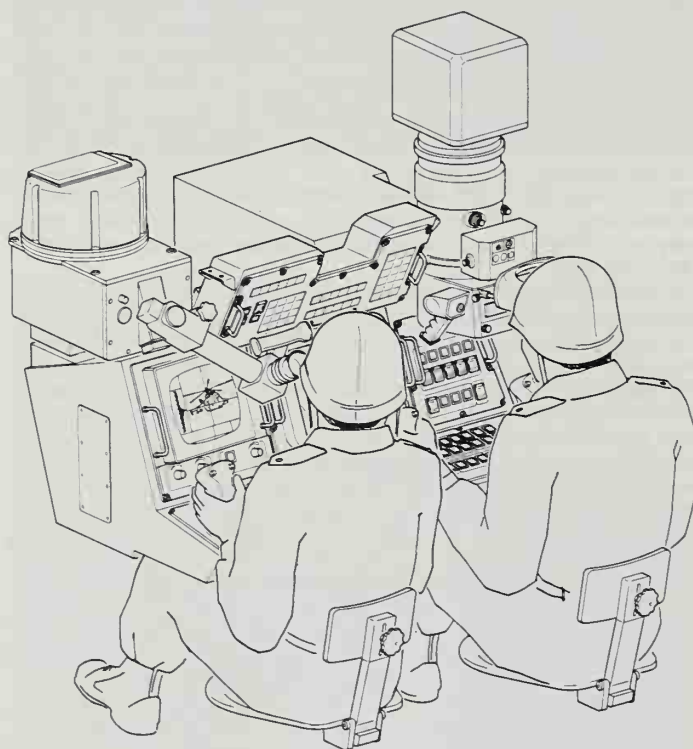
OTO Melara 76 mm OTOMATIC air defence tank on Palmaria SPG chassis showing position of main components (not to 1/76th scale)



OTO Melara 76 mm OTOMATIC air defence system on Leopard 1 MBT chassis with tracking and surveillance radars erected



OTO Melara 76 mm OTOMATIC air defence system on Leopard 1 MBT with APU to left of driver



Detailed drawing of commander's and gunner's position in OTO Melara 76 mm OTOMATIC air defence system

control is possible. The firing solution computer is inside the vehicle hull together with a gyro-stabilised navigation system to provide vehicle position data.

Prime contractor for the radar is SMA with the search radar being designated VPS-A05 and the tracking radar VPG-A06.

The fire control system performs the following main functions: target search, target designation, target classification (aircraft/helicopter), target identification (via IFF or optically), automatic target tracking (track while scan), threat analysis, automatic target acquisition, impact point prediction, gun aiming, optimisation of the fire burst duration and open fire.

The system has a backup configuration that increases the overall survivability of failures of the computer system and other subsystems. The command console is fully computer-controlled and operated to simplify the operator's action and built-in test equipment simplifies maintenance.

There are four smoke dischargers either side of the turret. An NBC overpressure air-conditioning protection system is also fitted, together with

an automatic fire extinguisher unit and a gas turbine auxiliary power unit to generate hydraulic electrical power and air-conditioning.

The computerised fire control system of the OTOMATIC enables it to provide real-time target information to other OTOMATIC systems with their radars switched off, or to other air defence systems, gun or missile, that do not have their own surveillance system installed.

The OTOMATIC turret may be mounted on any vehicle that can take a weight of 15 000 kg such as the medium MBT chassis from the Leopard 1 to the M1. In the case of the Leopard 1 the vehicle is known as the HEFAS76-L1 self-propelled gun and is a joint venture between Krupp MaK and OTO Melara.

#### SPECIFICATIONS (on Leopard 1 MBT chassis)

CREW	4
COMBAT WEIGHT	47 000 kg
POWER-TO-WEIGHT RATIO	18 hp/t
GROUND PRESSURE	0.96 kg/cm <sup>2</sup>
LENGTH GUN FORWARD	9.81 m
WIDTH	3.25 m
HEIGHT RADAR STOWED	3.07 m
GROUND CLEARANCE	0.44 m
TRACK WIDTH	550 mm
LENGTH OF TRACK ON GROUND	4.31 m
MAX ROAD SPEED	60 km/h
FUEL CAPACITY	955 l
MAX ROAD RANGE	500 km
FORDING WITHOUT PREPARATION	1.2 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	1.15 m
TRENCH	3 m
ENGINE	MTU MB 838 Ca M500, 10-cylinder multi-fuel developing 830 hp at 2200 rpm
TRANSMISSION	ZF 4 HP 250 planetary-gear shift with hydraulic torque converter, 4 forward and 2 reverse gears
STEERING	double differential
CLUTCH	torque converter with mechanical interlock
SUSPENSION	torsion bar
ELECTRICAL SYSTEM	24 V
BATTERIES	8 × 12 V, 100 Ah (each)
MAIN ARMAMENT	
calibre	76 mm
barrel length	62 calibre
rate of fire (cyclic)	120 rpm
muzzle velocity	910 m/s (A/A ammunition)
max range	16 000 m



elevation arc	-5 to +60°
elevation speed	45°/s
elevation angular acceleration	100°/s <sup>2</sup>
traverse arc	360°
traverse speed	70°/s
traverse angular acceleration	46°/s
ammunition types	HE, APFSDS, PFF (MON)
ammunition	
anti-aircraft	26 ready to fire
	26 stowed in turret
	26 stowed in vehicle
anti-tank	3 ready to fire
	9 stowed in turret
<b>AUXILIARY ARMAMENT</b>	
machine gun	1 × 7.62 mm
smoke dischargers	2 × 4
<b>FIRE CONTROL EQUIPMENT</b>	
search radar	solid MTI
frequency	S-band
maximum range (moving targets)	15 km (approx)
data rate	1 Hz (60 rpm)
IFF	integrated
tracking radar	monopulse, Cassegrain
frequency	K-band
maximum range (moving targets)	14 km (approx)
TV tracker	militarised daylight TV camera
	video format to CCIR standard
commander's periscope	binocular type, daylight operat
magnification	× 2.5 and × 10
field-of-view	20° and 5°
traverse	360°
elevation	-10 to +60°
gunner's periscope	monocular type, daytime operat
magnification	× 5
field-of-view	12°
traverse	45° left and right
elevation	-10 to +87°
laser rangefinder	Nd:YAG transmitter, 1.06 µm
repetition rate	10 Hz
beam divergence	1.2 to 3.5 mrad
daylight TV camera	silicon target VIDICON, video
	format to CCIR

**Status:** The first prototype was completed in 1987. The second prototype turret system, installed on a modified Leopard 1 MBT chassis, was completed in late 1990 and production systems could be delivered within two years of firm orders being placed.

**Manufacturer:** OTO Melara SpA, via Valdilocchi 15, I-19100 La Spezia, Italy.  
 Telephone: (39 187) 581111  
 Telex: 270368 2111010 OTO I  
 Fax: (39 187) 582669



OTO Melara 76 mm OTOMATIC air defence tank on Palmira SPG chassis from rear with tracking and surveillance radars in stowed position

## JAPAN

### Type 87 Twin 35 mm Self-propelled Anti-aircraft Gun System

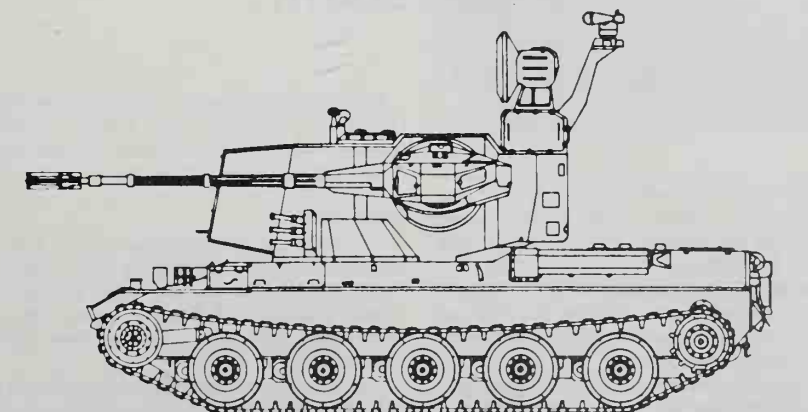
#### Development/Description

The Japanese Ground Self-Defence Force has a requirement for a new self-propelled anti-aircraft gun system to replace American-supplied M42 guns which are limited to clear weather use. The new system has the provisional designation of AW-X and consists of the modified chassis of the Type 74 MBT fitted with a new turret armed with twin 35 mm Oerlikon-Contraves KDA cannon and all-weather surveillance and tracking radars mounted on the roof at the turret rear.

For the AW-X application the sides of the Type 74 MBT have been raised slightly and are vertical to accommodate the new turret with its deeper basket. The access hatch to the right of the driver in the nose of the AW-X is where the auxiliary power unit is located.

Mounted externally on the left side of the tracking radar is a flat box which is believed to contain a laser rangefinder, optical tracker and possibly an LLLTV. The commander and gunner sit in the forward part of the turret and have a joint single-piece hatch cover that opens to the rear with gunnery sights to the front and two fixed observation periscopes either side.

The prime contractor for the fire control system is believed to be Mitsubishi-Denki with the Nippon Seiko-Jyo Company responsible for the armament. It was first delivered in 1980 with modified 35 mm KDA cannon delivered



Provisional drawing of AW-X SPAAG prototype on Type 74 MBT chassis



*The two prototypes of the Type 87 twin 35 mm self-propelled anti-aircraft gun system (Kensuke Ebata)*



*Type 87 twin 35 mm self-propelled anti-aircraft gun with tracking and surveillance radars erected*

initially in late 1979. Prototype turret, turret stabilisation and drive systems were produced in 1981 and full scale engineering of the total gun system began in 1982. The first complete prototype AW-X was assembled at the Sagami-hara works of Mitsubishi Heavy Industries in early 1984. Testing started later in the year.

Following extensive trials with two prototypes of the AW-X twin 35 mm self-propelled anti-aircraft gun system, it was type classified as the Type 87 self-propelled anti-aircraft gun system with the first production batch to consist of 12 vehicles.

**Status:** Production. In service with the Japanese Ground Self-Defence Force.

*Close up of the Type 87 twin 35 mm self-propelled anti-aircraft gun system (Kensuke Ebata)*



## KOREA, NORTH

### 14.5 mm Self-propelled Anti-aircraft Gun M1983

United States sources have stated that the North Korean Army has taken into service a self-propelled anti-aircraft gun system which has been designated the M1983. This is understood to consist of a full tracked

armoured chassis fitted with the North Korean built, Soviet designed, 14.5 mm ZPU-4 (quad) anti-aircraft gun system which has been provided with a fire control radar system to offer an increased first round hit probability. No further details of this system are available.

## KOREA, SOUTH

### Flying Tiger (Biho) Twin 30 mm Self-propelled Anti-aircraft Gun System

#### Development

The Flying Tiger twin 30 mm self-propelled anti-aircraft gun system has been developed to meet the specific requirements of the South Korean Army for a highly mobile self-propelled air defence system suited to the operational and terrain conditions of South Korea.

Key system requirements include good mobility and agility, day and night combat capability, four modes of operation (radar, semi-automatic, manual and ground), three man crew consisting of commander, gunner and driver and reaction time of between six and seven seconds.

At present South Korea has no self-propelled anti-aircraft guns in service apart from some quad 12.7 mm MGs mounted on the rear of 6 x 6 trucks. South Korean industry has manufactured a quantity of towed 20 mm M167 Vulcan air defence systems under licence.

It is understood that the prime contractor for the Flying Tiger is Daewoo Heavy Industries. Samsung Precision Instruments is responsible for the optronics package and Goldstar Electric Company, teamed with Siemens of Germany, is responsible for the search radar.

#### Description

The Flying Tiger consists essentially of a stretched version (with six instead of the normal five road wheels either side) of the Korean Infantry Fighting Vehicle (KIFV) which has been in quantity production by the Special Products Division of Daewoo Heavy Industries Limited for some years, fitted with a new power operated turret armed with twin 30 mm rapid fire cannon.

The two-man all-welded aluminium turret is mounted in the centre of the roof with the electro-optical tracking device situated on the front of the turret between the two 30 mm cannon, this sensor package elevates with the cannon. Total weight of the turret is about 4.5 t.



The cannon are believed to be 30 mm Oerlikon-Contraves weapons with a cyclic rate of fire of 660 rds/gun/min each one being provided with 250 rounds of ready use ammunition. The weapons have an effective anti-aircraft range of about 3000 m with each barrel being fitted with a muzzle velocity measuring system which feeds information to the system's onboard computer.

Turret traverse and weapon elevation is electric with manual controls being provided for emergency use. Turret traverse is 360° with elevation from -10 to +85°. Traverse speed is 90°/s.

Mounted on the turret rear is the German Siemens MPDR 18X search radar which has an effective range of about 15 km. When not required this folds down to the rear of the turret.

Standard equipment includes built-in test equipment, an IFF system and an ECCM capability.

Total weight of the system in an operating configuration is about 16 t with the 320 hp diesel engine, which is coupled to a T320 fully automatic transmission, giving a power to weight ratio of 20 hp/t. The system is not amphibious but can ford to a depth of 1 m.

**Status:** Prototype undergoing trials with the South Korean Army.

**Prime contractor:** Special Project Division, Daewoo Heavy Industries Limited, 23rd Floor Daewoo Center Building, 541 Namdaemonno 5-ga, Chung-gu Seoul, South Korea.

Telephone: 777 1856

Telex: 23301/CPO Box 7955

## 20 mm Self-propelled Anti-aircraft Gun System

### Development

The South Korean Army has recently taken into service a 20 mm clear weather self-propelled anti-aircraft gun system to provide air defence cover for its mechanised units.



### Description

This system consists essentially of a modified Korean Infantry Fighting Vehicle (KIFV) chassis (*Jane's Armour and Artillery 1991-92* page 377) fitted with an unmanned 20 mm Vulcan air defence turret system which is identical to that fitted to the US General Electric M163 20 mm Vulcan self-propelled anti-aircraft gun system covered later in this section.

**Status:** Production. In service with the South Korean Army.

**Manufacturers:** Chassis: Special Project Division, Daewoo Heavy Industries Limited, 23rd Floor Daewoo Center Building, 541 Namdaemonno 5-ga, Chung-gu Seoul, South Korea.

Telephone: 777 1856

Telex: 23301/CPO Box 7955

20 mm Vulcan gun system: Daewoo Heavy Industries Limited, 6 Manseog-Dong, Dong-Gu, Incheon, South Korea.

Telephone: (132) 72 - 1011

Telex: K23301

*Air defence version of Korean Infantry Fighting Vehicle armed with 20 mm Vulcan air defence system*

## M55 Quad 12.7 mm Self-propelled Anti-aircraft Gun System

The South Koreans have manufactured 12.7 mm Quadruple M55 anti-aircraft machine gun mountings and fitted them on the rear platform of M35 series trucks for low altitude air defence and ground operations.

**Status:** Production complete. In service with the South Korean Army.



*South Korean M55 self-propelled anti-aircraft gun system on M35 (6 × 6) truck (Kensuke Ebata)*

## SOUTH AFRICA

## Ystervark 20 mm Self-propelled Anti-aircraft Gun System

## Development

The Ystervark was developed to meet an urgent South African requirement for an armoured self-propelled anti-aircraft gun system which could also be used for escorting convoys. It was first deployed in the Operational Area (Namibia) in the mid-1980s and during fighting in 1988 successfully engaged and shot down a number of high-performance jet aircraft of the Angolan Air Force.

Prior to the introduction of the Ystervark, the South African Army used a Buffel (4 × 4) tractor fitted with a similar weapon, but these lacked armour protection when compared to the Ystervark.

## Description

The Ystervark 20 mm self-propelled anti-aircraft gun system essentially consists of a SAMIL 20 (4 × 4) 2 t truck chassis which is provided with full length protection for mines, armoured engine compartment at the front and in the driver's cab to the right, the 20 mm Oerlikon-Contrares GAI-C01 cannon, fully described in the *Towed Anti-Aircraft Guns* section, is mounted on top at the rear. An armoured cabin is provided to protect the gun detachment from shell splinters and small arms fire. The position of the 20 mm cannon is such that its field of fire is about 200° through the rear arc.



Ystervark 20 mm SPAAG on SAMIL 20 truck chassis

The Ystervark has a combat weight of 7.7 t and is powered by a diesel engine giving a maximum road speed of 93 km. The 200 litre fuel tank gives an operating range of 950 km.

**Status:** Production complete. In service with the South African Army.

## SWEDEN

## Combat Vehicle 90 Air Defence System (CV 90 AA)

## Development/Description

HB Utveckling AB, a company jointly owned by Bofors and Hägglunds Vehicle, are developing the Combat Vehicle 90 family of full tracked vehicles for the Swedish Army.

The air defence member of this family is designated the CV 90 AA, with the first prototype being completed and handed over to the Swedish Army in December 1991, for extensive trials commencing in 1992.

The CV 90 AA air defence version is similar to the Pbv G mechanised infantry combat vehicle, having the same two man turret armed with a Bofors 40 mm L/70 cannon, but does not carry the eight fully equipped troops in the rear of the vehicle.

Mounted on the turret rear is the search radar which can detect aircraft and hovering helicopters. There are two competing radars to meet this requirement, the French Thomson-CSF Gerfaut TRS 2620 and the Swedish Ericsson HARD (Helicopter and Airplane Radio Detection). When travelling the radar is retracted into the safety of the turret bustle although it can be erected and operating while the vehicle is moving.



Prototype of the Combat Vehicle 90 AA prototype with Thomson-CSF Gerfaut search radar mounted on turret rear

The air defence version of the Combat Vehicle 90 will have a six man crew consisting of driver in hull front, vehicle commander and gunner in the turret (on the left and right respectively) and the remaining three crew members in the rear of the vehicle. The latter are the radar operator, combat controller and external co-ordinator.

The Bofors 40 mm L/70 gun is called the 40/70B and is based on the ordnance of the well known towed anti-aircraft gun, but for this application it is inverted with the ammunition being fed from the bottom and the cartridge cases being ejected through the turret roof.

Under the breech of the 40 mm L/70 gun is the magazine which is divided into three compartments with eight rounds in each. Depending on the tactical situation, each magazine would contain a different type of ammunition with the change from one compartment to another being accomplished by a hydraulic device.

The 40 mm gun can fire single shots, bursts or full automatic fire and has an elevation of +50° and a depression of -8°, with turret traverse being a full 360°.

Ammunition is loaded into each of the three magazines manually, one by one, with eight rounds being loaded in about 20 seconds. Reserve ammunition would be stowed in the turret floor.

Types of ammunition fired by the 40/70B gun include the well known Bofors PFHE for use against aircraft and helicopters, HE-T for engaging ground targets and TP-T. For engaging combat vehicles at ranges of 1500 to 2000 m an APFSDS-T round has been developed with a tungsten rod penetrator. The APFSDS-T round has a muzzle velocity of 1470 m/s, compared with that of the HE-T and PFHE Mk 2 of 1025 m/s.

The hull of the Combat Vehicle 90 family is of all welded steel armour construction with an additional layer of advanced armour for added protection.

The engine compartment is at the front of the hull on the right side with an access plate in the glacis plate. The driver sits on the left with a rear opening single piece hatch cover and three periscopes for forward observation, the centre one of which can be replaced by a passive periscope for night driving.

The vehicle is powered by a Scania DS 14 diesel engine developing 550 hp coupled to a X-300-4B fully automatic transmission with torque converter and lock up clutch, which has four forward and two reverse gears.

To keep the profile of the Combat Vehicle as low as possible, the radiators are positioned to the right side of the hull rear.

The two man turret is in the centre with the remaining crew members being seated at the rear of the vehicle and enter via a large door in the hull rear.

Suspension is of the torsion bar type with each side consisting of seven rubber tyred road wheels, drive sprocket at the front and idler at the rear.

Standard equipment includes NBC system and fire detection and suppression system.



**OUTLINE SPECIFICATIONS**

CREW	6
COMBAT WEIGHT	20 000 kg
POWER-TO-WEIGHT RATIO	27.5 hp/t
GROUND PRESSURE	0.46 kg/cm <sup>2</sup>
LENGTH OF CHASSIS	6.4 m
WIDTH	3.1 m
HEIGHT	2.5 m
GROUND CLEARANCE	0.45 m
LENGTH OF TRACK ON GROUND	3.9 m
MAX ROAD SPEED	70 km/h
MAX RANGE	300 km
ENGINE	Scania diesel developing 550 hp
TRANSMISSION	Allison Transmission Division of General Motors X-300-4B fully automatic transmission with torque converter with 4 forward and 2 reverse gears
STEERING	clutch and brake

ELECTRICAL SYSTEM	24 V
ARMAMENT	1 × 40 mm cannon
SMOKE DISCHARGERS	2 × 6
TURRET TRAVERSE	360°
ELEVATION/DEPRESSION	+50°/-8°

**Status:** Prototype undergoing trials with the Swedish Army. Not yet in production or service.

**Manufacturer:** Swedish Ordnance, S-691 80 Karlskoga, Sweden.

Telephone: (46) 586 81000

Telex: 73210 sweords

Fax: (46) 586 58145

Hägglands Vehicle AB, S-891 82 Ornskoldsvik, Sweden.

Telephone: (46) 660 80819

Telex: 6051 Haeggs

Fax: (46) 660 82649

## UNION OF SOVIET SOCIALIST REPUBLICS

### ZSU-57-2 Twin 57 mm Self-propelled Anti-aircraft Gun System

#### Development

The ZSU-57-2 was developed in early 1951 and was first seen in public during a parade in Moscow in November 1957. ZSU is the Soviet designation for self-propelled anti-aircraft gun, 57 is for the calibre of the guns (57 mm) and 2 is for the number of guns. The system consists of a chassis based on T-54 components but with much thinner armour, four rather than five road wheels and a large open-topped turret armed with twin 57 mm S-68 guns which have the same performance and use the same ammunition as the towed single S-60 anti-aircraft gun which is fully described in the *Towed Anti-Aircraft Guns* section. ZSU stands for *Zenitnaia Samokhodnaia Ustanovka* (self-propelled anti-aircraft mount).

The weapon was originally deployed in Soviet tank and motorised rifle divisions but has now been replaced in first-line service by the much more effective ZSU-23-4 system. The ZSU-57-2 entered front line service with the Soviet Army in 1955 and is usually referred to by them as the Pair (or Sparka).

#### Description

The all-welded hull of the ZSU-57-2 is divided into three compartments: driver's at the front, fighting in the centre and engine at the rear.

The driver is seated at the front of the hull on the left and has a single-piece hatch cover that opens to the left, in front of which are two periscopes, one replaceable by an infra-red periscope which is used in conjunction with the infra-red headlamp mounted on the right side of the glacis plate. Mounted at right angles to the glacis plate is a narrow board to stop water rushing up when the vehicle is fording shallow rivers.

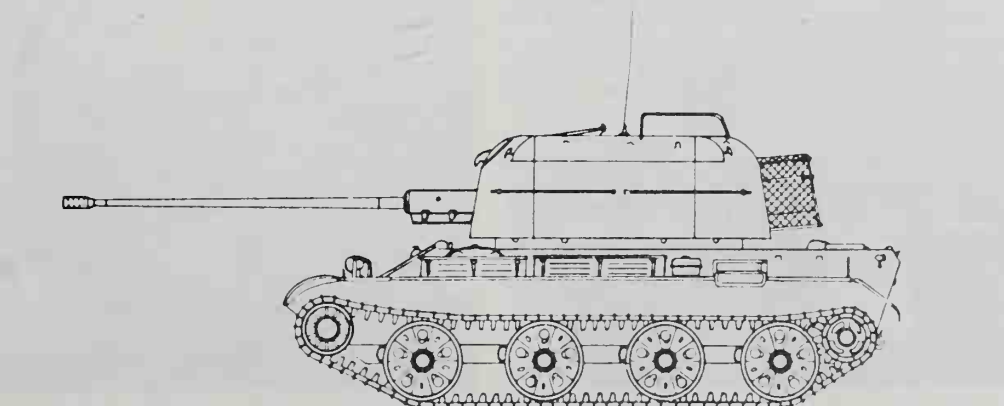
The large turret has slightly sloping sides, well curved corners and is fitted with external grab rails on either side. The engine, mounted transversely at the rear of the hull, is provided with a compressed-air system for cold weather starting; for normal use there is an electric starter. The air-inlet and air-outlet louvres are in the roof of the engine compartment at the rear with the exhaust outlet on the left track guard.

The torsion bar suspension consists of four dual rubber-tyred road wheels with the drive sprocket at the rear, idler at the front but no return rollers. The first and last road wheel stations are provided with a hydraulic shock absorber. The all-steel track has steel pins that are not secured at the outer end and are free to travel towards the hull. A raised piece of metal welded to the hull just forward of the drive sprocket drives the track pins into position each time they pass.

The ZSU-57-2 has no NBC system and no amphibious capability. It is believed that the vehicle is not fitted with a smoke-laying system similar to that on T-54/T-55 and T-62 tanks. Long-range fuel drums can be fitted to the rear of the hull to increase the operational range of the ZSU-57-2.

Main armament of the ZSU-57-2 consists of twin 57 mm S-68 cannon with 24 lands and grooves, an elevation of +85°, depression of -5°, and 360° turret traverse. Elevation, depression and turret traverse are powered, with manual controls available for emergency use. The ammunition, in clips of five rounds, is fed to the magazines each side of the weapon by a loader seated in the forward part of each side of the turret. The right-hand gun is modified to be loaded from the right so as to avoid loading problems. There are two gun aimer/pointers (vertical and horizontal) with each having an automatic anti-aircraft sight, so that there would not be a lag or delay in engaging a target, the designers provided for hydro-electric drives for laying with handwheels as a back up for both elevation and traverse. In addition, in case the automatic sight was disabled a simplified mechanical sight was also provided for.

The guns are fully automatic, recoil-operated, and each gun has a cyclic rate of fire of 105 to 120 rds/min with a practical rate of fire of 70 rds/gun/min. Maximum horizontal range is 12 000 m, maximum vertical range 8000 m, although effective ranges are less than this. Effective slant range is 3993 m, effective altitude limit with weapons elevated at +45° is 2835 m and effective altitude limit with weapons elevated at +65° is 4237 m. The weapon does not have the same effective anti-aircraft range as the towed S-60, as the latter can be used in conjunction with off-carriage fire control equipment. Fire control for the ZSU-57-2 is achieved by an optical mechanical computing reflex sight. The maximum traverse rate is 30°/s and the maximum elevation rate 20°/s. The weapons can fire the following types of fixed ammunition:



ZSU-57-2 twin 57 mm self-propelled anti-aircraft gun



ZSU-57-2 with turret traversed to right

AMMUNITION TYPE	FRAG-T	FRAG-T	APC-T
PROJECTILE DESIGNATION	OR-281	OR-281U	BR-281*
FUZE MODEL	MG-57	MG-57	MD-10
FUZE TYPE	PD SD	PD SD	BD
WEIGHT OF PROJECTILE	2.81 kg	2.85 kg	2.82 kg
BURSTING CHARGE			
weight	0.168 kg	0.154 kg	0.018 kg
type	RDX/Alum	RDX/Alum	RDX/Alum
MUZZLE VELOCITY	1000 m/s	1000 m/s	1000 m/s
ARMOUR PENETRATION AT			
0° OBLIQUITY	n/app	n/app	96 mm/ 1000 m

\* also very similar BR-281U

The Yugoslav Federal Directorate of Supply and Procurement produce an HE-T round for the ZSU-57-2 and the towed S-68 and details of this are as follows:

AMMUNITION TYPE	HE-T
DESIGNATION	M66
FUZE	impact, super quick action with pyrotechnical self-destruction
COMPLETE ROUND	
weight	6.386 kg
length	536 mm
PROJECTILE	
weight	2.85 kg
length	258 mm
FUZE MATERIAL	steel
PROJECTILE BODY MATERIAL	steel
TYPE OF BURSTING CHARGE	RDX/Alum
CARTRIDGE CASE	brass
PROPELLING CHARGE	NC powder
GUN PRIMER	fulminate
MUZZLE VELOCITY	1000 m/s

The ammunition is not interchangeable with that used in the 57 mm ASU-57 air-portable self-propelled anti-tank gun or towed anti-tank guns. The empty cartridge cases and clips are deposited on a conveyor belt which runs under the weapons. This takes the cases and clips to the rear of the turret where they are deposited in the wire cage mounted externally on the turret rear. A total of 300 rounds of ammunition are carried in clips of five rounds. Cyclic rate of fire is 120 rounds per barrel per minute.

The main drawback of the ZSU-57-2 is its lack of an all-weather fire control system but it is highly effective in the ground role and is capable of destroying most AFVs on the battlefield with the exception of MBTs, and even those would be very vulnerable to penetration by the 57 mm APHE projectile on their sides and rear.

Late production ZSU-57-2 SPAAGs were fitted with a more sophisticated sighting system. This model is identified by two small ports in the forward upper portion of the turret front.



Polish Army ZSU-57-2

### Variant

China is producing the Type 80 self-propelled anti-aircraft tank which uses a Type 69 II MBT chassis fitted with a Chinese built copy of the turret of the ZSU-57-2. Additional details of this are given in this section under China.

### SPECIFICATIONS

CREW	6
COMBAT WEIGHT	28 100 kg
POWER-TO-WEIGHT RATIO	18.56 hp/t
GROUND PRESSURE	0.63 kg/cm <sup>2</sup>
LENGTH	
guns forward	8.46 m
guns rear	7.43 m
hull	6.22 m
WIDTH	3.27 m
HEIGHT	2.71 m
FIRING HEIGHT	2.05 m
GROUND CLEARANCE	0.425 m
TRACK	2.64 m
TRACK WIDTH	580 mm
LENGTH OF TRACK ON GROUND	3.84 m
MAX ROAD SPEED	50 km/h
FUEL CAPACITY	812 l (+ 400 l auxiliary)
MAX ROAD RANGE	420 km (595 km with auxiliary fuel)
FUEL CONSUMPTION	1.9 l/km
FORDING	1.4 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.8 m
TRENCH	2.7 m
ENGINE	model V-54, V-12 water-cooled diesel developing 520 hp at 2000 rpm
TRANSMISSION	manual with 5 forward and 1 reverse gears
STEERING	clutch and brake
CLUTCH	multi-plate
SUSPENSION	torsion bar
ELECTRICAL SYSTEM	28 V
BATTERIES	4 × 12 V, 280 Ah
ARMAMENT	2 × 57 mm guns
AMMUNITION	300
GUN CONTROL EQUIPMENT	
turret power control	powered/manual
gun elevation/depression	+85°/-5°
turret traverse	360°
ARMOUR	
hull glacis	13.5 mm at 58.8°
hull rear	10.6 mm at 45°
hull upper	15 mm at 0°
hull lower	13.5 mm at 0°
turret (all round)	13.5 mm curved

**Status:** Production complete. In service with the following countries:



Country	Quantity	User	Comment
Angola	40	army	
China, People's Republic	50-100	army	more of locally built model called Type 80
Cuba	25+	army	
Egypt	40	army	
Finland	12	army	to be replaced
Iran	80	army	status uncertain
Iraq	100+	army	exact number uncertain

Country	Quantity	User	Comment
Korea, North	250+	army	
Mozambique	20+	army	
Romania	60	army	unconfirmed
Syria	100+	army	
USSR	750	army	held in reserve
Vietnam	100+	army	
Yugoslavia	100+	army	

**Manufacturer:** Soviet state factories.

## 2S6 Quad 30 mm/SA-19 Self-propelled Air Defence System

### Development

In 1986 a new self-propelled air defence system entered service with the Group of Soviet Forces Germany (since renamed the Western Group of Forces) which was given the US/NATO designation M1986.

It is now known that the correct Soviet industrial designation of this system is the 2S6 and that it was developed by the Ministry of Radio Industry of the USSR and the Scientific Production Corporation Phasotron.

The 2S6 is the replacement for the older ZSU-23-4 system and is armed with four 30 mm cannon and eight SA-19 SAMs. The missiles would be used to engage targets at long range with the cannon engaging close-in targets. The eight missiles would enable a number of multiple targets to be engaged without reloading as no spare missiles are carried on the vehicle.

Compared with the ZSU-23-4, the 2S6 has improved cross-country mobility, better fire control systems and a mix of guns and missiles that enable more targets to be acquired and killed at much increased ranges.

The exact composition of a 2S6 battalion is not clear and it may well be used in conjunction with the SA-16 manportable SAM system carried in BMP-2 infantry fighting vehicles.

It is possible that a mobile Dog Ear forward alerting radar is allocated at battalion headquarters or at battery headquarters to give as much warning as possible of approaching targets. An illustration of the Dog Ear radar system is given in the entry for the SA-13 'Gopher' low altitude surface-to-air missile system.

### Description

In overall layout the 2S6 is very similar to the German Gepard twin 35 mm self-propelled air defence system on a modified Leopard 1 chassis which is in service with the Belgian, German and Netherlands armies.

Initial reports, including the US Government publication, *Soviet Military Power*, indicated that the 2S6 was mounted on a T-72 MBT chassis, but it is now clear that it is based on the medium armoured transporter family that evolved from the GM-539 tracked vehicle. The same chassis is also used with the SA-11 'Gadfly', SA-15 (SA-8 follow-on) as well as their associated support vehicles.

The layout of the vehicle is conventional, with the driver seated at front left, the turret in the centre and the engine and transmission at the rear. The driver has a single-piece hatch cover over his position and immediately in front of this are three periscopes. To his immediate front is a hatch cover in the glacis plate which is raised when driving in a non-combat area for improved forward visibility.

The turret has vertical sides with the commander's cupola being well forward on the right side. This has a single-piece hatch cover which opens to the rear and three periscopes giving observation to the front. On the forward part of the hatch is an infra-red searchlight. There is another hatch cover, opening to the rear, in the centre of the turret.

Suspension is of the hydro-pneumatic type with six equally spaced road wheels, drive sprocket at the rear, idler at the front and three track return rollers. When travelling, the suspension is lowered to provide maximum possible ground clearance, but when in the firing position it is raised and locked out to provide a more stable firing platform. It is estimated that the vehicle height is changed by 250 to 200 mm when the suspension is locked out.

The 2S6 is probably powered by a derivative of the V-59 diesel engine used on the 2S3/2P24/GMZ chassis although in this application the engine is supplemented by a 50 kW turbine system to allow it to operate with the main engine switched off. The air inlet and air outlet for the main engine are located in the left rear side of the hull.

The power operated turret is mounted in the centre of the hull and is armed with two twin 30 mm cannon, one pair of which is mounted externally on either side of the turret.

The cannon used in the 2S6 are much longer than those of the BMP-2 and are mounted in pairs with the right cannon having the appearance of being slightly to the rear of the left cannon and is provided with a muzzle velocity measuring system.

No firm details of the ammunition used by the 30 mm cannon are available although it is known that the 30 mm 2A42 dual-feed cannon installed in the BMP-2 fires both HE-T and AP-T ammunition and has two rates of fire, 200/300 or 500 rpm. The empty cartridge cases of the 30 mm cannon in the 2S6, and probably the links, are ejected out of the turret.

Although the maximum vertical range of the weapons is probably around 5000 m, the maximum effective anti-aircraft range is around 3000 m.

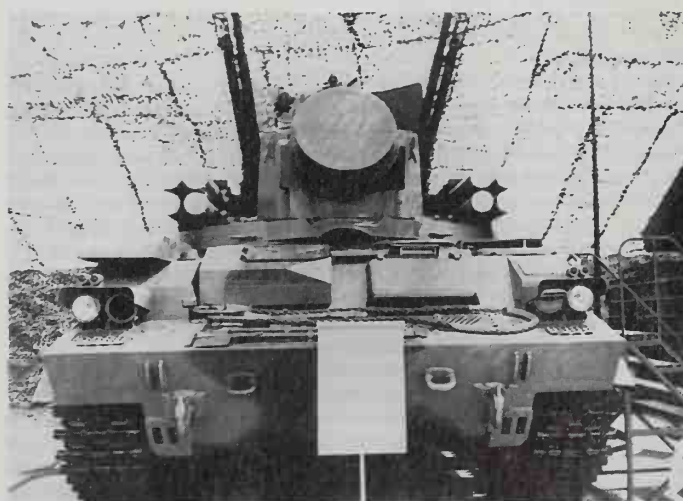
According to Soviet sources, the 2S6 can engage targets flying at a maximum speed of 500 m/s with the complete system having a reaction time of eight seconds. Effective range of the complete system is from 0.2 to 8 km according to Soviet sources.

The SA-19 missiles are mounted four either side of the twin 30 mm cannon and have independent elevation indicating they are probably of the fire-and-forget type. However, it is equally possible that they are of SACLOS (semi-automatic command to line-of-sight) type with an IR terminal seeker.

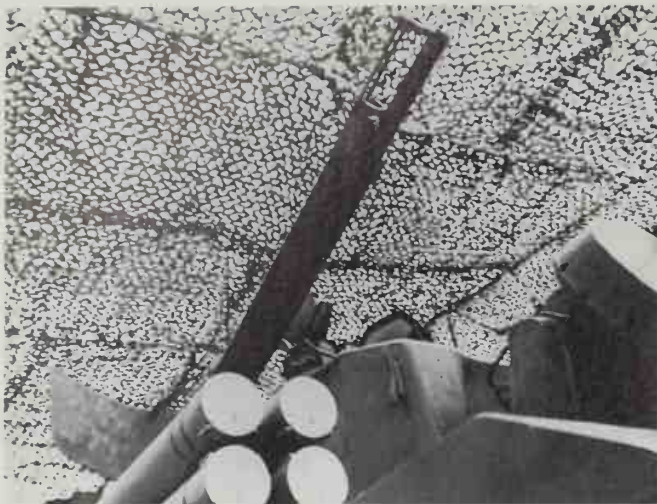
The SA-19 is believed to be the same as that used in the Soviet Navy's CADS-1 (SA-N-11) system installed on the *Kalinin*, the third member of the Kirov class. This CIWS however has a different sensor system and two six-barrelled Gatling type weapons.



Scale model of the 2S6 Quad 30 mm/SA-19 self-propelled air defence system (Robert Karniol)



2S6 showing tracking radar mounted on forward part of turret and packs of SA-19 SAMs in horizontal position



Close up of right-hand twin 30 mm cannon of 2S6 showing four SA-19s below



Close up of left bank of four SA-19 SAMs and surveillance radar on roof of turret at rear

The SA-19 has an approximate range of 8 km and are kept in sealed containers and reloaded in clips of two missiles. The estimated length of the missile is 2 m and it has a launch weight of 30 kg, of which 8 kg is the high explosive warhead. Some sources have indicated that the missile could be semi-active laser guided, infra-red or command radar.

The missiles are probably launched in pairs for increased kill probability. Protection is provided for the rear, sides and top of the missile canisters, this may be armoured or more probably be made of sheet steel to avoid damage by trees and bushes. To the immediate rear of the launcher is a blast deflector.

The weapons can be used when the vehicle is moving but greater accuracy would be obtained if stationary and the hydro-pneumatic suspension is locked out.

The earlier ZSU-23-4 has a single roof-mounted radar that can carry out both tracking and surveillance roles whereas the 2S6 has individual tracking and surveillance radars in a similar manner to that of the German Gepard.

The overall system is called the Hot Shot by NATO with the surveillance and target acquisition radar being mounted on the turret roof at the rear, this folds down 90° to the turret rear when not required so reducing the overall height of the system and reducing possible damage from trees and other terrain obstacles. This radar has a maximum effective range of at least 18 km.

Mounted on front of the turret is the fire control radar which tracks the target and has a range of between 8 and 10 km. On the left side of the turret roof are the optical sights which may have both day and night capability as well as being used in a heavy ECCM environment. There are at least two types of roof-mounted optical sights, the earlier system being somewhat similar to that of the older ZSU-23-4 system. The second arrangement is

believed to be a new design and incorporates a day/night capability. One of the roof sights is probably used with the SA-19 SAMs.

A laser rangefinder is probably incorporated as well, as the system presumably includes an IFF interrogator which interacts with the usual Khrom-Nikel (Odd Rods) IFF system found on Soviet combat aircraft. The turret has seats for three crew members.

#### SPECIFICATIONS (Provisional)

CREW	4
COMBAT WEIGHT	34 000 kg
LENGTH	7.84 m
WIDTH	3.47 m
HEIGHT	
radar up	3.89 m
radar down	3.08 m
MAX TURRET DIAMETER	1.42 m
TRACK WIDTH	600 mm
MAX ROAD SPEED	65 km/h
ENGINE	V-59 diesel derivative developing 520 hp
APU	50 kW turbine
ARMAMENT	4 × 30 mm cannon
	8 × SA-19 SAM
AMMUNITION	1904 × 30 mm

**Status:** In production. In service with the USSR.

**Manufacturer:** Soviet state factories.

## ZSU-23-4 Quad 23 mm Self-propelled Anti-aircraft Gun System

### Development

The main drawback of the twin 57 mm ZSU-57-2 (qv) self-propelled anti-aircraft gun was its slow rate of fire and lack of any radar or fire control system. In the late 1950s the Astrov KB design bureau started work on the new system, it consisted of a chassis based on the PT-76 light amphibious tank fitted with a new turret and four water-cooled AZP-23 guns. It was being developed as a twin towed air-defence system and was to enter service as the ZU-23 (qv). The turret was also fitted with an acquisition and tracking radar which supplied information to the fire control computer.

ZSU is the Soviet designation *Zenitnaia Samokhodnaia Ustanovka* (self-propelled anti-aircraft mount), 23 is the calibre of the weapons (23 mm) and 4 represents the number of weapons in the system. The common Soviet name for the ZSU-23-4 is the *Shilka* (Awl).

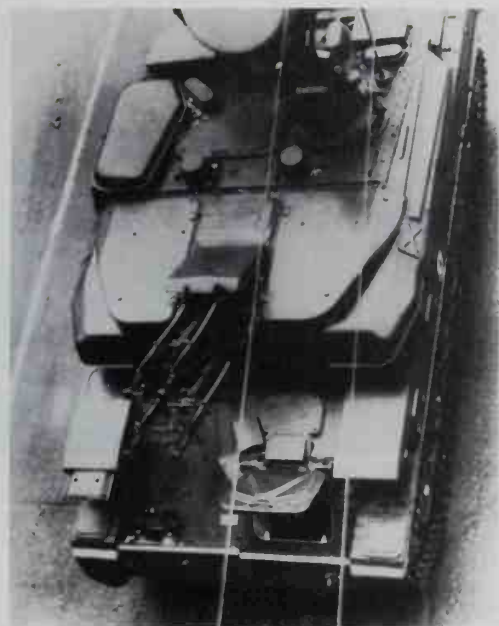
The first prototypes were completed in the early 1960s with troop trials being carried out in 1963-64. It was first seen in public during a parade held in Red Square, Moscow, in November 1965. Production commenced in 1965 with first units becoming operational in 1966 and production continued until 1983. In addition to being produced in the USSR, it was also undertaken under licence in Czechoslovakia. Total production was between 6000 and 7000 units.

The ZSU-23-4 was first used operationally by Egypt and Syria during the 1973 Middle East conflict where it accounted for about 30 per cent of the



ZSU-23-4V1 of the Hungarian Army with driver's and commander's hatches open and clearly showing splash board across glacis plate of vehicle





*ZSU-23-4M model 1977 clearly showing modifications to turret compared to early production models (US Army)*

aircraft lost by the Israeli Air Force. On its own the ZSU-23-4 can be overcome but used in conjunction with other Soviet air defence systems such as the SA-6, it is highly effective.

It has replaced the clear weather ZSU-57-2 self-propelled anti-aircraft gun in front-line units and is issued on the scale of four ZSU-23-4s per Soviet Motorised Rifle and Tank Regiment anti-aircraft battery (with four SA-9 or SA-13 vehicles) to give a total of 16 ZSUs per Motorised Rifle and Tank Division. They usually operate in pairs with approximately 150 to 200 m between the individual vehicles. In the Soviet Army the ZSU-23-4 is now being supplemented by the new 30 mm 2S6 air defence gun/missile system.

#### Description

The all-welded steel hull of the ZSU-23-4 is divided into three compartments: driver's at the front, fighting in the centre and the engine at the rear.

The four man crew of the ZSU-23-4 consists of the commander, search and aiming operator, ranging operator and driver/mechanic.

The driver is seated at the front of the vehicle on the left and has a single-piece hatch cover to his front that opens upwards on the outside. When it is raised a windscreen and wiper can be positioned in front of the driver. When the driver's hatch is closed, forward observation is maintained by a BM-130 periscope which can be replaced by an infra-red TVN-2 periscope for night driving. Either side of the driver's position is a vision block.

Mounted on the lower part of the glacis plate is a splash board to stop water rushing up the front of the vehicle when it is fording a stream.

The other three crew members; commander, search radar operator/gunner and range operator, are all seated in the large square turret. The guns and ammunition are in the forward part of the turret and separated from the crew by a gas-tight and armoured bulkhead. Access to the guns and ammunition is by two large hatches, one either side of the turret roof, which are hinged in the centre and open vertically. The commander is seated on the left side of the turret and has a cupola which can be traversed 360°. The cupola has a single-piece hatch cover that opens to the rear and, in the forward part, three periscopes, the centre one a TPKU-2 which can be replaced by a TKN-1T infra-red periscope for night use. This has a range of 200 to 250 m. The commander also has an infra-red searchlight mounted on the forward part of the cupola.

To the right of the commander is a large single-piece hatch cover that opens to the rear in front of which are two BM-190 periscopes.

The engine and transmission are at the rear of the hull as is the DG4M-1 80 hp gas turbine. The torsion bar suspension system consists of six single rubber-tyred road wheels with the idler at the front and the drive sprocket at the rear. There are no track return rollers. Hydraulic shock absorbers are provided for the first and last road wheel stations.

Standard equipment on all vehicles includes an air filtration and overpressure NBC system, FG-125 infra-red driving lights and a vehicle navigation system for both the driver and commander which allows them to plot their exact position at any given time. An R-123 radio is used for communications.

Main armament comprises four AZP-23M 23 mm cannon (basically the same guns used on the towed ZU-23) with an elevation of +85°, depression of -4°, and 360° turret traverse. The 23 mm cannon is gas operated with a



*ZSU-23-4M model 1977 clearly showing modifications to turret compared to early production models and splash board fitted across lower glacis plate*

vertically moving breech-block locking system which drops to unlock, and has a cyclic rate of fire of 800 to 1000 rds/barrel/min. The ZSU-23-4 can engage targets using only one or two of the four cannon. Normally bursts of three to five, five to ten or a maximum of 30 rounds per barrel are fired. The barrels are water-cooled and are provided with flash-hiders. The weapons have a maximum effective anti-aircraft range of 2500 m and a maximum effective ground range of 2500 m. A total of 2000 rounds of 23 mm ammunition is carried in 40 box magazines containing 50 belted rounds each. The following types of fixed ammunition are fired:

API-T with the projectile weighing 0.189 kg and a muzzle velocity of 970 m/s, which will penetrate 25 mm of armour at a range of 500 m and 19.3 mm at 1000 m

HEI-T with the projectile weighing 0.19 kg and a muzzle velocity of 970 m/s.

Each ammunition belt of 500 rounds contains one API-T and three HEI-T rounds in sequence. Supply trucks which follow the ZSUs at a distance of 1.5 to 2.5 km carry an additional 3000 rounds for each of the vehicles.

The fire control system consists of the radar, sighting device, computer, line-of-sight and line-of-elevation stabilisation units.

The radar, which has the NATO designation Gun Dish, operates in the J-band, is mounted at the rear of the turret and the 1 m diameter antenna can be folded down to the turret rear to reduce the overall height of the vehicle for air transport. The radar performs search, detection, automatic tracking, range to target and angular position. Range of the radar in a panoramic search mode is said to be up to 20 km and in the target-tracking mode up to 18 km. An optical sight enables the weapons to be used in an ECM environment. The ZSU-23-4 can fire while stationary, on the move at speeds up to 25 km/h or on slopes with inclinations up to 10°. However, gunfire accuracy is reduced by up to half when firing on the move. The onboard fire control radar is subject to ground clutter interference when employed against targets flying below 200 m or so.

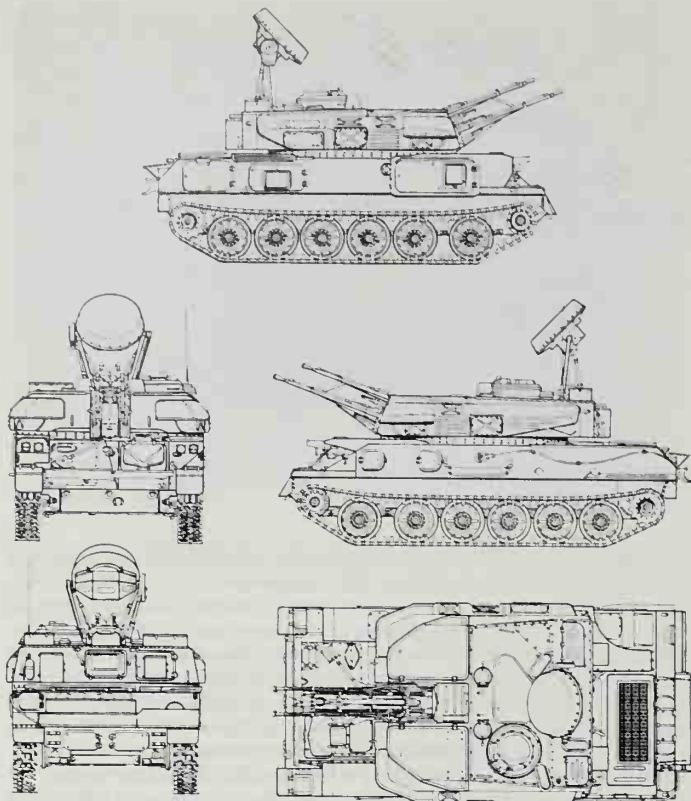
The ZSU-23-4 is fitted with a complicated onboard stabilisation system that stabilises both the line-of-sight to the target as well as the firing direction.

A typical target engagement is believed to take place as follows: the search operator/gunner and range operator first observe the target on their scope when the radar is being used for surveillance or sector scan. If required the target data can also be accepted from other target acquisition or tracking radars of the division. If the target is confirmed as hostile the radar is switched to automatic tracking and target data is fed into the computer for determining the gun lead angle. When the target is in effective range of the weapons the computer advises the commander or scan-operator and the guns are fired. The weapons can be aimed when the vehicle is travelling across country and can also be laid without the use of the radar, computer or stabilisation system. Acquisition, lock-on and firing takes 20-30 seconds. The ZSU-23-4 is credited with being 50 per cent more accurate than the American Vulcan anti-aircraft system and having a 66 per cent greater effective range than the same system.

If the radar of the ZSU-23-4 is jammed or senses an incoming missile, the radar automatically shuts itself down with the gunner then engaging the target using his optical sighting system.

#### Variants

At least nine identifiable separate versions of the ZSU-23-4 have been seen. These include the ZSU-23-4 model 1965 (pre-series version), the ZSU-23-4 model 1965 (initial production version), the ZSU-23-4V model 1968, the ZSU-23-4V1 model 1972 and the ZSU-23-4M model 1977. Most differ only in stowage, external fittings or cooling vents. Large ammunition panniers, mounted on the turret sides, were introduced in an intermediate production model. The latest variant, the ZSU-23-4M features these panniers, three (instead of two) access ports on each side of the hull and an armoured cover for the guns. It also has a digital computer, an improved



ZSU-23-4V1 Model 1972 (not to 1/76th scale) (Steven Zaloga)

Gun Dish radar and can be linked to off-carriage radar and fire control equipment if required. The Gun Dish radar on the ZSU-23-4M is capable of being used independently in the search mode whereas on previous versions it had been slaved to the gun tubes.

In 1985 a modified ZSU-23-4M was seen with protrusions on the right and left sides of the Gun Dish radar dome and vanes down its centre. The vanes are side-lobe clutter-reducing devices and the protrusions are IFF receivers.

The most significant changes in late production versions of the ZSU-23-4 have included a major change to the air cooling supply system as well as the radio and electronic systems of the vehicle. These changes have improved the overall reliability of the system. An improved ventilation system for the fighting and crew compartments has been installed.

#### SPECIFICATIONS

CREW	4
COMBAT WEIGHT	20 500 kg
POWER-TO-WEIGHT RATIO	20 hp/t
GROUND PRESSURE	0.69 kg/cm <sup>2</sup>
LENGTH	6.54 m
WIDTH	2.95 m
HEIGHT	
with radar	3.8 m
without radar	2.25 m
FIRING HEIGHT	
(lower guns)	1.83 m
GROUND CLEARANCE	0.4 m
TRACK	2.67 m
TRACK WIDTH	360 mm
LENGTH OF TRACK ON GROUND	3.8 m
MAX ROAD SPEED	44 km/h
FUEL CAPACITY	250 l
MAX RANGE	450 km
FUEL CONSUMPTION	0.96 l/km
FORDING	1.07 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	1.1 m
TRENCH	2.8 m
ENGINE	model V-6R, 6-cylinder in-line water-cooled diesel developing 280 hp



ZSU-23-4 self-propelled anti-aircraft gun system ready for rail transport with four 23 mm cannon covered up and search radar stowed to rear

TRANSMISSION	manual with 5 forward and 1 reverse gears
SUSPENSION	torsion bar
ELECTRICAL SYSTEM	24 V
ARMAMENT	4 × 23 mm cannon
SMOKE-LAYING EQUIPMENT	none
AMMUNITION	2000
UNIT OF FIRE	2000 rounds
GUN CONTROL EQUIPMENT	
turret power control	powered/manual
by commander	yes
by gunner	yes
gun elevation/depression	+85°/-4°
turret traverse	360°
max traverse speed	70°/s
max elevation speed	60°/s
ARMOUR	
glacis plate	15 mm at 55°
hull sides	15 mm
turret front	9.2 mm at 15°
turret sides	9.2 mm
turret rear	9.2 mm

**Status:** Production complete. In service with the following countries:

Country	Quantity	User	Comment
Afghanistan	20	army	
Algeria	210	army	
Angola	20+	army	
Bulgaria	35	army	
Congo	8	army	
Cuba	36	army	
Czechoslovakia	100	army	licence built
Egypt	117	army	
Ethiopia	60	army	
Hungary	14	army	
India	75	army	
Iran	100+	army	
Iraq	200+	army	status uncertain
Israel	60	air force	
Jordan	44	air force	
Korea, North	100+	army	
Laos	10+	army	
Libya	250	army	
Nigeria	30	army	
Peru	35	army	
Poland	87	army	
Somalia	4	army	
Syria	300	army	
USSR	n/av	army	also naval infantry
Vietnam	100+	army	
Yemen	50+	army	

**Manufacturer:** Czechoslovakian and Soviet state factories.



## BTR-40A and BTR-152A Twin 14.5 mm Self-propelled Anti-aircraft Gun Systems

### Development

The BTR-40A and BTR-152A twin self-propelled weapons were developed in the late 1940s and were originally designed to provide long-range fire support to motor rifle battalions with a secondary air defence capability. They have long since been replaced by new systems although some remain in service in the Third World as they are simple to operate and maintain and can also be used in an urban/counter-insurgency role.

The BTR-40A entered service in 1950 and is essentially a BTR-40 (4 × 4) APC with a ZTPU-2 mount in the rear whilst the BTR-152A, which entered operational service in 1952, is a BTR-152 (6 × 6) APC with a similar arrangement.

### Description

Both vehicles have an all-welded steel hull with the engine at the front, commander and driver in the centre and the twin 14.5 mm turret mounted at the rear. The driver sits on the left of the vehicle with the vehicle commander to his right, and it has a windscreen which can be covered by an armoured shutter hinged at its upper part. The shutter has a vision block for observation when it is lowered. Both the commander and driver have a door in the side of the hull, the upper part being a vision flap that hinges open on the outside and has a vision slit.

A spare wheel is carried on the rear of the hull in the centre and a saw is often carried on the left side of the hull.

Neither vehicle has an NBC system or night vision equipment and they are not amphibious. The BTR-40A is not fitted with a central tyre pressure regulation system although the later models of the BTR-152A do have such a system.

The turret is fitted with twin 14.5 mm KPV heavy machine guns that have manual traverse through 360° and manual elevation from -5° to +80°.

The 14.5 mm machine guns have a maximum horizontal range of 8000 m and a maximum vertical range of 5000 m but effective anti-aircraft range is 1400 m and effective range in the ground role is 2000 m.

The KPV machine gun has a cyclic rate of fire of 600 rds/barrel/min but its practical rate of fire is 150 rds/barrel/min and it is air-cooled.

The API (BS 41) projectile weighs 64.4 g and has a muzzle velocity of 1000 m/s penetrating 32 mm of armour at a range of 500 m. The API-T

(BZT) projectile weighs 59.6 g and the I-T (ZP) projectile weighs 59.68 g. Approximately 2400 rounds of boxed ammunition are carried for ready use.

Both the BTR-40A and BTR-152A are clear weather systems with no provision for off carriage fire control although target information such as speed, range and altitude can be provided over the radio net.

The 14.5 mm KPV machine gun is also used in the ZPU-1 (single barrel), ZPU-2 (twin barrel) and ZPU-4 (quad barrel) covered in the *Towed Anti-Aircraft Guns* section.

### Variants

#### BTR-152D with Twin 14.5 mm ZPU-2 Mount

The BTR-152D is essentially the same as the BTR-152A vehicle but has the chassis of the BTR-152V APC which entered service in 1955 and which is fitted with a central tyre pressure regulation system.

#### BTR-152E with Quad 14.5 mm ZPU-4 Mount

This is the BTR-152V chassis fitted with the quadruple ZPU-4 mount. Only a small number were produced and as far as is known, none now remain in service.

#### BTR-152 with Twin 23 mm ZU-23

During the fighting in the Lebanon in the summer of 1982 the Israeli Army captured a number of BTR-152 APCs from the PLO which were fitted with the towed automatic anti-aircraft gun ZU-23 in the rear of the troop compartment. The twin 23 mm ZU-23 has a maximum range of 2500 m in the anti-aircraft role. Full details are given in the *Towed Anti-Aircraft Guns* section.

#### BTR-152 with M53 MGs

Many years ago the Egyptians fitted a number of their BTR-152s with the Czechoslovakian quad 12.7 mm M53 anti-aircraft gun system which consists of four Soviet designed 12.7 mm DShK machine guns on a Czechoslovakian designed two-wheeled mount. Full details of the M53 are given in the *Towed Anti-Aircraft Guns* section. A small number of these systems have been seen in Afghanistan and used by the Afghan Government for convoy escort work.

### SPECIFICATIONS

MODEL	BTR-40A	BTR-152A
CREW	4-5	4-5
CONFIGURATION	4 × 4	6 × 6
COMBAT WEIGHT	5800 kg	9600 kg
POWER-TO-WEIGHT RATIO	13.7 hp/t	11.45 hp/t
LENGTH	5 m	6.83 m
WIDTH	1.9 m	2.32 m
HEIGHT		
overall	2.5 m	2.8 m
hull top	1.75 m	2.05 m
FIRING HEIGHT	2.05 m	2.35 m
GROUND CLEARANCE	0.275 m	0.295 m
TRACK		
front	1.588 m	1.742 m
rear	1.6 m	1.742 m
WHEELBASE	2.7 m	3.3 m + 1.13 m
MAX ROAD SPEED	80 km/h	65 km/h
FUEL CAPACITY	120 l	300 l
MAX ROAD RANGE	285 km	780 km
FUEL CONSUMPTION		
(road)	0.42 l/km	0.46 l/km
FORDING	0.8 m	0.8 m
GRADIENT	60%	55%
SIDE SLOPE	30%	30%
VERTICAL OBSTACLE	0.47 m	0.6 m
TRENCH	0.7 m	0.69 m
ENGINE MODEL	GAZ-40	ZIL-123
TYPE	6 cylinder	6 cylinder
COOLING	water	water
OUTPUT/RPM	80 hp/3400 rpm	110 hp/3000 rpm
TRANSMISSION TYPE	manual	manual
GEARS	4F/1R	5F/1R
TRANSFER BOX	none	2-speed
CLUTCH	single dry plate	twin dry plate
TYRES	9.75 × 18	12.00 × 18
BRAKES	hydraulic drum on all wheels	
ELECTRICAL SYSTEM	12 V	12 V
ARMOUR	8 mm	13.5 mm

**Status:** Production complete. A full list of users of the BTR-40 and BTR-152 is provided, although in many cases these are used by second line units or held in reserve, some of these are known to use the BTR-40A or BTR-152A anti-aircraft vehicles:



BTR-152A twin 14.5 mm SPAAG, late production vehicle with central tyre pressure regulation system



BTR-152 fitted with 23 mm ZU-23 mm automatic anti-aircraft gun mounted in rear (Israel Defence Forces)



BTR-152 (6 x 6) APC in Afghanistan fitted with Czechoslovakian quad M53 AAG



BTR-40A twin 14.5 mm SPAAG

Country	BTR-40	BTR-152
Afghanistan	yes	yes
Albania	yes	yes
Algeria	no	yes
Angola	no	yes
Bulgaria	yes (R)	yes (R)
Burundi	yes	no
Cambodia	yes	yes
Central African Republic	no	yes
China, People's Republic	yes	yes
Congo	no	yes
Cuba	yes	yes
Egypt	yes	yes
Equatorial Guinea	yes	no
Ethiopia	yes	yes
Guinea	yes	yes
Guinea-Bissau	yes	yes
Hungary	no	yes (R)
Indonesia	yes	yes
Iran	yes	yes
Iraq	no	yes

Country	BTR-40	BTR-152
Korea, North	yes	yes
Laos	yes	yes
Mali	no	yes
Mongolia	no	yes
Mozambique	yes	yes
Nicaragua	yes	yes
Poland	no	yes (R)
Romania	no	yes (R)
Somalia	yes	yes
Sri Lanka	no	yes
Sudan	no	yes
Syria	yes	yes
Tanzania	yes	yes
Uganda	yes	yes
USSR	yes (R)	yes (R)
Vietnam	yes	yes
Yemen	yes	yes
Yugoslavia	yes	yes
Zaire	yes	no
Zimbabwe	no	yes

## UNITED KINGDOM

### Marconi Marksman Twin 35 mm Anti-aircraft Turret

#### Development

Following a worldwide market survey into the type of air defence system required to protect armoured and mechanised formations and units from the low level fighter ground attack aircraft and pop-up helicopter threat, the then Marconi Command and Control Systems commenced development in 1983 of a prototype of the Marksman twin 35 mm anti-aircraft turret. This was in response to identified requirements for a system which could be rapidly fitted to an existing chassis, had fast reaction and high lethality with the maximum possible range and which would operate in all weather by day and night.

The principal feature of the Marksman gun turret is that it is a completely self-contained turret which can be fitted to any main battle tank hull or large armoured personnel carrier hull without modification. This retrofit philosophy has also been adopted to provide point defence for fixed localities such as airfields, radar sites, coastal installations and oil rigs by fitting the turret to a prepared ground installation. The 35 mm guns are considered by Marconi to provide the optimum balance of the requirements of range, lethality and accuracy and the combined surveillance and tracking radar gives fast reaction with an all-weather day and night capability.

Marconi Radar and Control Systems has three partners in the project: Vickers Defence Systems of Newcastle who manufacture the armoured turret, Oerlikon-Contraves who supply the 35 mm cannon and the new ammunition transfer system and Société de Fabrication d'Instruments de Mesure (SFIM) of France who supply the gyro-stabilised sights and inertial reference system. Integration of Marksman is carried out by Marconi at its Leicester works.

The first prototype was complete in 1984 with a turret of mild steel, while the second, fully armoured and equipped to production standard, was completed in 1985. The two turrets have allowed Marconi to retain one for trials and development work while the other is used for demonstrations at

home and abroad. Trials have been successfully conducted both in the UK and overseas in conditions varying from hot desert to arctic winter and in temperatures ranging from -36 to +42°C. The turret has undergone trials and tests on a number of different tank hulls, including T-55, Type 59, M48, Centurion, Challenger 1, Chieftain and Vickers Mk 3. The average time to fit the turret to a tank hull is about two hours.

In December 1988 the Finnish Ministry of Defence placed an order worth FM75 million (£10 million) for an initial quantity of Marksman twin 35 mm anti-aircraft turrets, training, spares, test equipment and on site support.

By early 1991 the initial batch of production Marksman turrets had been delivered to Finland and installed on T-55 tank chassis for protection of the armoured brigade. The supply of a further quantity of turrets is currently under discussion.



Marconi Radar and Control Systems Marksman twin 35 mm anti-aircraft turret in fixed point defence mounted in a concrete installation (artist's impression)





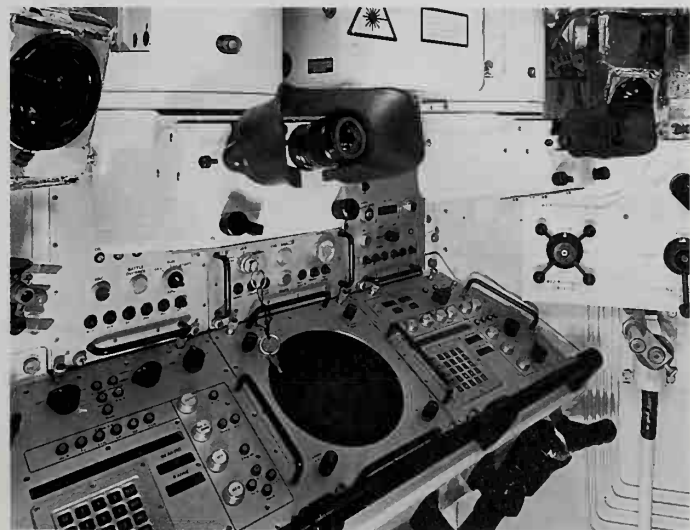
Marconi Radar and Control Systems Marksman twin 35 mm anti-aircraft turret on Finnish Army T-55 MBT chassis

### Description

The Marksman anti-aircraft gun turret consists of a self-contained armoured turret fitted with twin rapid-firing 35 mm Oerlikon KDA cannon, together with an automatic highly ECM-resistant surveillance and tracking radar, fixed or gyro-stabilised optical sights and a modern digital fire control system.

The radar used with the system is the Marconi 400 series combined surveillance and tracking radar which utilises a single antenna. The decision to fit just one radar was taken for various reasons, including quicker reaction time, reliability, cost and weight. The radar is therefore smaller and lighter than previous short range air defence radars and the radar equipment, mounted in the turret hull, is of modular design. The radar rotates at 60 rpm, operates in the X/J-band and has a range of 12 km in the surveillance mode. Tracking range is 10 km. It provides fully automatic operation, has a particularly good ECCM capability because of its very wide bandwidth and frequency agility and has been designed to minimise the effects of rain attenuation and to overcome the problem of secondary ground reflection (multi-path) effects. The radar is mounted on the turret roof and is stabilised to enable it to operate in surveillance on the move. If required, the director can be swung backwards by 180° for stowage in a travelling position reducing the overall height of the vehicle.

Two SFIM Type VS 580-VISAA roof-mounted sights are provided together with a high PRF laser rangefinder. These may be either fixed sights slaved to the gun boresight or independent gyro-stabilised fully panoramic optical sights. The sights not only provide an alternative mode of operation if for any tactical or operational reason the radar cannot be used, but also visual identification and verification of radar engagements. The two gyro-stabilised sights when used in conjunction with the radar give the crew three independent means of surveillance and tracking. This allows the crew considerable flexibility particularly against multiple targets, permitting extremely rapid switches from one target to another. The gunner's sight includes a fixed aiming graticule for the engagement of surface targets.



Commander's and gunner's position in Marconi Radar and Control Systems Marksman anti-aircraft turret



Marconi Radar and Control Systems Marksman twin 35 mm anti-aircraft turret on Type 59 MBT chassis

Target data from the radar or optical sights is passed in digital form to a modern digital fire control system which is based on a modified version of Marconi designs currently in service in main battle tanks. The fire control system produces accurate output signals which are used by the electric turret drives to track the target and correctly aim the guns. It also indicates when the weapon system is ready and able to engage the target.

The Marksman turret is fitted with two Oerlikon 35 mm KDA cannon mounted externally on each side of the turret on large diameter bearings. The cannon was selected by Marconi as the optimum gun solution due to its combination of range, lethality, excellent terminal effects, high muzzle velocity, rate of fire and proven performance. The KDA cannon and mount are identical to those installed on the Gepard twin 35 mm self-propelled anti-aircraft gun system in service with Germany (420), Belgium (55) and the Netherlands (95). They are, however, of the latest standard with an improved lubrication system.

Each cannon has 230 rounds of anti-aircraft and 20 rounds of armour-piercing ammunition for engaging ground targets. A major feature of Marksman is that a total ammunition reload, so critical on the battlefield, takes well under 10 minutes. Each cannon is provided with an ammunition container mounted inside the turret which feeds ammunition through the transfer system via the elevation bearings to the cannon. The ammunition containers are readily replaced using a small davit on the side of the turret. Alternatively a separate vehicle equipped with a crane could be used. Each cannon has a cyclic rate of fire of 550 rds/min and a maximum effective range of 4000 m. Sufficient ammunition is carried for between 15 and 20 engagements before ammunition resupply is necessary. The KDA cannon fires the following types of fixed ammunition:

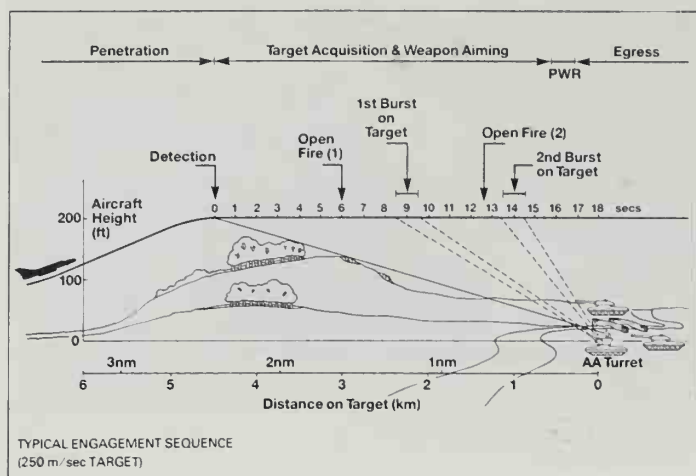
AMMUNITION TYPE	APDS-T	HEI	HEI-T	SAPHEI-T	TP	TP-T
WEIGHT						
projectile	294 g	550 g	535 g	550 g	550 g	550 g
propellant	330 g	330 g	330 g	330 g	330 g	330 g
explosive	none	80 g+	98 g	22 g	none	none
		20 g				
complete round	1460 g	1580 g	1565 g	1552 g	1580 g	1580 g
EXPLOSIVE TYPE	none	Hexal	Hexal	Hexal	none	none
LENGTH						
complete round	370 mm	387 mm	387 mm	387 mm	387 mm	387 mm
MUZZLE VELOCITY	1385 m/s	1175 m/s	1175 m/s	1175 m/s	1175 m/s	1175 m/s
FLIGHT TIME						
to 1100 m	0.75 s	0.96 s	0.96 s	0.96 s	0.96 s	0.96 s
to 2000 m	1.58 s	2.18 s	2.18 s	2.18 s	2.18 s	2.18 s
to 3000 m	2.51 s	3.78 s	3.78 s	3.78 s	3.78 s	3.78 s

Under development by Oerlikon-Contraves is a new range of 35 mm ammunition with increased muzzle velocities and therefore reduced flight times to target as well as major advances in fuzing.

The cannon are located externally to the turret shell so no fumes can affect the crew and to allow the empty cartridge cases and links to be ejected outside the turret. To compensate for the effect of barrel wear on muzzle velocity, which in turn affects time of flight and hence aim-off distances, each barrel is fitted with measuring equipment which measures the muzzle velocity of every projectile fired and feeds the information into the fire control system.

The cannon can be elevated from -10 to +85° at a maximum speed of 60°/s with turret traverse through a full 360° at up to 60°/s.

Marksman is fitted with the latest solid-state stabilised turret drive system with electronics, servo controls, solid-state power amplifiers and batteries being positioned on the floor of the turret basket, below which is a rotary base junction. The turret batteries have a combined capacity of 300 Ah and provide sufficient power to run the complete turret for some time without recharge, thus allowing the turret to operate in a silent watch mode at a moment's readiness. The batteries are recharged by an auxiliary diesel



Typical Marksman anti-aircraft turret target engagement sequence

generator mounted on the rear of the turret. The tank engine can also be used for this purpose in an emergency.

The Marksman turret is of all-welded steel construction and over its frontal arc provides complete protection from 14.5 mm API ammunition fired by the Soviet KPVT heavy machine gun, with protection being provided against 7.62 mm armour-piercing ammunition over the remainder. Protection is also provided against 155 mm airburst artillery projectiles. As an option the turret can be fitted with an NBC system, as space for this is provided each side of the generator. Other equipment, such as radio installations, would be to the requirements of the user.

The Marksman turret is normally operated by a crew of two: commander and gunner, although one-man operation is possible. The commander and gunner sit side by side in front of an ergonomically designed console which allows either crew member full access to the fire control system as well as to an independent optical sight. The console includes a centrally located radar display and incorporates all the operator interfaces required for the radar, gun control equipment and power distribution within the turret. The comprehensive built-in test equipment (BITE) facility is controlled and monitored at the console. An optional IFF panel is fitted above the console.

Marksman is designed to operate fully automatically from the initial acquisition of a target by the radar to a 'ready to fire' indication to the crew. This is achieved by a variable guard zone which is set up on the radar display using the commander's keypad on the central console. With the radar in surveillance in the automatic mode, any target entering the airspace covered by the guard zone will be automatically interrogated by the IFF, if fitted, and if hostile, acquired and tracked. The only action required by the crew is to press the fire button. The system reaction time in the automatic mode is under five seconds (4.5 seconds average on trials). Targets that appear outside the guard zone can be manually designated using a marker on the radar display, after which the sequence will proceed as for a target acquired automatically. Targets can also be designated to the radar using the optical sights.

In the optical mode, the target is acquired and tracked using the sights which, together with a built-in laser rangefinder, provide target data to the fire control system to calculate aim-off.

The turret can be mounted on any main battle tank or large APC hull without modification to either the turret or the hull. It is designed to fit directly to a T-tank hull; for other tank chassis a simple adaptor ring is required. A simple electrical connection is made to enable the turret crew to

communicate with the driver. Connection of the turret to the electrical system of the tank is not required as the turret has its own power supply; however an interface is provided to allow the use of the tank engine in an emergency.

The turret can also be fitted to a prepared ground installation which may be as simple or as elaborate as desired.

#### SPECIFICATIONS (Turret)

##### RADAR

###### TYPE

Marconi Series 400 surveillance and tracking radar - X/J-band coherent frequency agile

###### RANGE

surveillance

12 km

tracking

10 km

###### TARGET SPEED

up to 400 m/s

###### ANTENNA

offset front fed parabolic dish

###### RECEIVER

monopulse MTI and digital signal processing

##### OPTICAL SIGHT

GYRO-STABILISED or

FIXED TRAVERSE

dual FOV 5° × 10 and 18° × 3

dual FOV 7° × 8 and 40° × 1

Each with integral laser rangefinder

##### CANNON

###### TYPE

two Oerlikon KDA stabilised in 2 axes

###### CALIBRE

35 mm

###### MAX EFFECTIVE RANGE

4000 m

###### MUZZLE VELOCITY

1175-1385 m/s ammunition type dependent

###### RATE OF FIRE

550 rds/min/barrel

###### ELEVATION/DEPRESSION

+85°/-10°

###### AMMUNITION

HEI, HEI-T, TP, TP-T, SAPHEI-T, APDS-T 230 AA per barrel (containerised) 20 APDS per barrel

##### SYSTEM

###### CREW

2 (commander and gunner)

###### REACTION TIME

alarm to ready to fire under 5 s (automatic)

###### POWER SUPPLY

28 V from turret batteries recharged by the turret APU

###### FIRE CONTROL

automatic digital

###### POWER DRIVES

electric solid state

###### TRAVERSE

360° at up to 60°/s

###### WEIGHT OF TURRET

11 000 kg

###### OVERALL LENGTH WITH GUNS

radar up 7.12 m

radar stowed 7.585 m

###### OVERALL WIDTH

3.45 m

###### HEIGHT

radar up 2.705 m

radar down 1.910 m

###### TURRET RING DIAMETER

1.99 m

**Status:** In service with Finland on T-55 MBT chassis. Tested on seven MBT chassis types.

**Manufacturer:** Marconi Radar and Control Systems Limited, New Parks, Leicester LE3 1UK, UK.

Telephone: (0533) 871481

Telex: 34551

Fax: (0533) 871746

## UNITED STATES OF AMERICA

### M42 Twin 40 mm Self-propelled Anti-aircraft Gun System

#### Development

At the end of the Second World War the standard tracked self-propelled anti-aircraft gun of the United States Army was the twin 40 mm M19. It was a member of the Light Combat Team, all of which shared the same basic chassis and included the M24 light tank, M37 105 mm howitzer motor carriage and the M41 155 mm howitzer motor carriage.

In August 1951 authorisation was given to design, develop and build prototypes of a twin 40 mm self-propelled anti-aircraft gun (designated the T141 interim vehicle), twin 40 mm self-propelled anti-aircraft gun (designated the T141E1 ultimate vehicle) and a carrier fire control vehicle (designated

the T53). In May 1952 the T141E1 and its associated T53 fire control vehicle were cancelled. The T141 was designed by the Cadillac Motor Car Division of the General Motors Corporation with the first prototype being completed late in 1951. The T141 had a very short development period as it was based on components of the M41 light tank which was also being produced by the Cadillac Motor Car Division of the General Motors Corporation at the Cleveland Tank Plant and used the same turret with twin 40 mm guns as the earlier M19A1.

The T141 was standardised as the Gun, Twin 40 mm, Self-propelled, M42, in October 1953, after the vehicle had already been in production for more than a year.

The M42 was in production at Cleveland Tank Plant from late 1951 to June 1956 and at ACF Industries Incorporated of Berwick, Pennsylvania, from early 1952 to December 1953. Production of the M42 amounted to





M42 twin 40 mm self-propelled anti-aircraft gun system used by Taiwan with locally produced 32-round magazine above 40 mm weapon (DTM)

3700 units. To improve the fuel economy and increase operational range a fuel injection system was designed for the AOS-895-3 engine. The fuel injection model became known as the AOSI-895-5 and trials showed fuel savings of 20 per cent. In February 1956 the basic M42 was reclassified as limited standard and the M42A1 as standard. Most M42s were subsequently brought up to M42A1 standard.

The M42 was replaced in front-line service with the United States Army by the 20 mm Vulcan Air Defense System from 1969, but it remained in service with the US Army National Guard until 1990-91 when it was finally phased out of service.

#### Description

The all-welded steel hull of the M42 is divided into three compartments: driver's and commander's at the front, turret in the centre and the engine at the rear.

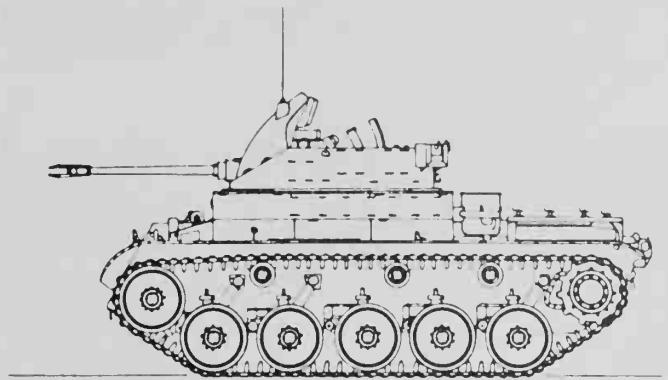
The driver is seated at the front of the hull on the left with the commander/radio operator to his right. Both have a single-piece hatch cover that opens to the outside of the vehicle, with a single M13 periscope which can be traversed through 360°. The other four crew members are seated in the open-topped turret in the centre of the vehicle.

The engine compartment at the rear of the hull is separated from the fighting compartment by a fireproof bulkhead and has a fire extinguisher operated by the driver. The engine is mounted towards the front of the engine compartment and the transmission at the rear.

The torsion bar suspension consists of five dual rubber-tyred road wheels with the idler at the front, drive sprocket at the rear and three track return rollers. The first, second and fifth road wheel stations have a hydraulic shock absorber. The steel tracks have replaceable rubber pads.

The M42 has no amphibious capability or NBC system but most vehicles were fitted with infra-red driving lights.

Main armament comprises twin 40 mm cannon M2A1 in mount M2A1 in a turret with a traverse of 360°. The weapons have hydraulic elevation from -3 to +85° and manual operation from -5 to +85°. The weapons are recoil operated, have vertical sliding breech-blocks and the gunner can select either single shots or full automatic. Early vehicles had flash-hiders but they were replaced on later production vehicles by flash suppressors which were subsequently retrofitted to the earlier vehicles. Practical rate of fire is



M42 self-propelled anti-aircraft gun

120 rds/barrel/min, maximum anti-aircraft range is 5000 m and maximum ground-to-ground range is 9475 m. The following types of fixed ammunition can be fired:

AP-T (M81 series) with the complete round weighing 2.077 kg, muzzle velocity of 872 m/s;

HE-T with the complete round weighing 2.15 kg, muzzle velocity of 880 m/s;

TP-T (M91) with the complete round weighing 2.14 kg, muzzle velocity of 872 m/s.

Of 480 rounds of 40 mm ammunition carried, most is stored in the ammunition containers along the tops of the track guard either side of the turret. Three sighting devices are incorporated into the fire control system of the M42: computing sight M38, reflex sight M24C and the speed ring sight. The computing sight M38 is designed to provide an effective means of controlling fire of the 40 mm cannon against both air and ground targets. The reflex sight M24C is designed to superimpose a graticule pattern in the gunner's line-of-sight and is used in conjunction with the computing sight M38 during power operation. The speed ring sight is used during manual operation if a power failure or local control system malfunction occurs.

Mounted on the left rear of the turret is a 7.62 mm (0.30) M1919A4 machine gun, which has been replaced by an M60 MG in the United States Army. The machine gun has a traverse of 360°, elevation of +76° to the front and an elevation of +60° at the rear.

#### Breda M42 Upgrade

The Italian company of Breda Meccanica Bresciana is now offering a new fully enclosed armoured turret armed with a single 40 mm L/70 gun for installation on the current M42 chassis with little modification.

The turret is of all-welded steel armour construction which varies in thickness from 9 to 16 mm and this provides the same degree of protection as the hull. Both the commander and gunner are provided with a cupola with observation devices for all round observation and the gunner, seated on the left, has a roof-mounted periscopic sight.

The 40 mm L/70 gun has a dual-feed ammunition system and can be used to engage aircraft, helicopters and ground targets.

The gunner controls the turret functions when operated through the optical sight and the tracking radar. The second crewman, the commander, is seated on the right and operates the 7.62 mm roof-mounted machine gun. Both turret crew members carry out loading and reloading of the magazine.

Ammunition can be loaded via a hatch in each side of the turret towards the rear and the empty 40 mm cartridge cases are ejected from the turret automatically. In addition to the ready rounds stowed in the on-gun magazine and in the existing external racks on either side of the hull, over 60 additional rounds are also stowed inside the turret. These will be stowed forward of the commander's and gunner's seats.

The 40 mm L/70 gun has a cyclic rate of fire of 450 rds/min and in addition to firing the existing types of 40 mm L/70 ammunition it will also fire a new APFSDS round.

The rate of fire is 50 per cent more than the standard L/70 weapon and this has been achieved by a private venture research and development programme carried out by Breda. The modifications have included the use of stronger materials, reducing recoil length and installation of a new ramming system.

The ready use magazine holds a total of 90 rounds of fixed ammunition including a quantity for engaging ground targets.

Turret traverse and weapon elevation is hydraulic with turret traverse through a full 360° and weapon elevation from -3 to +80°.

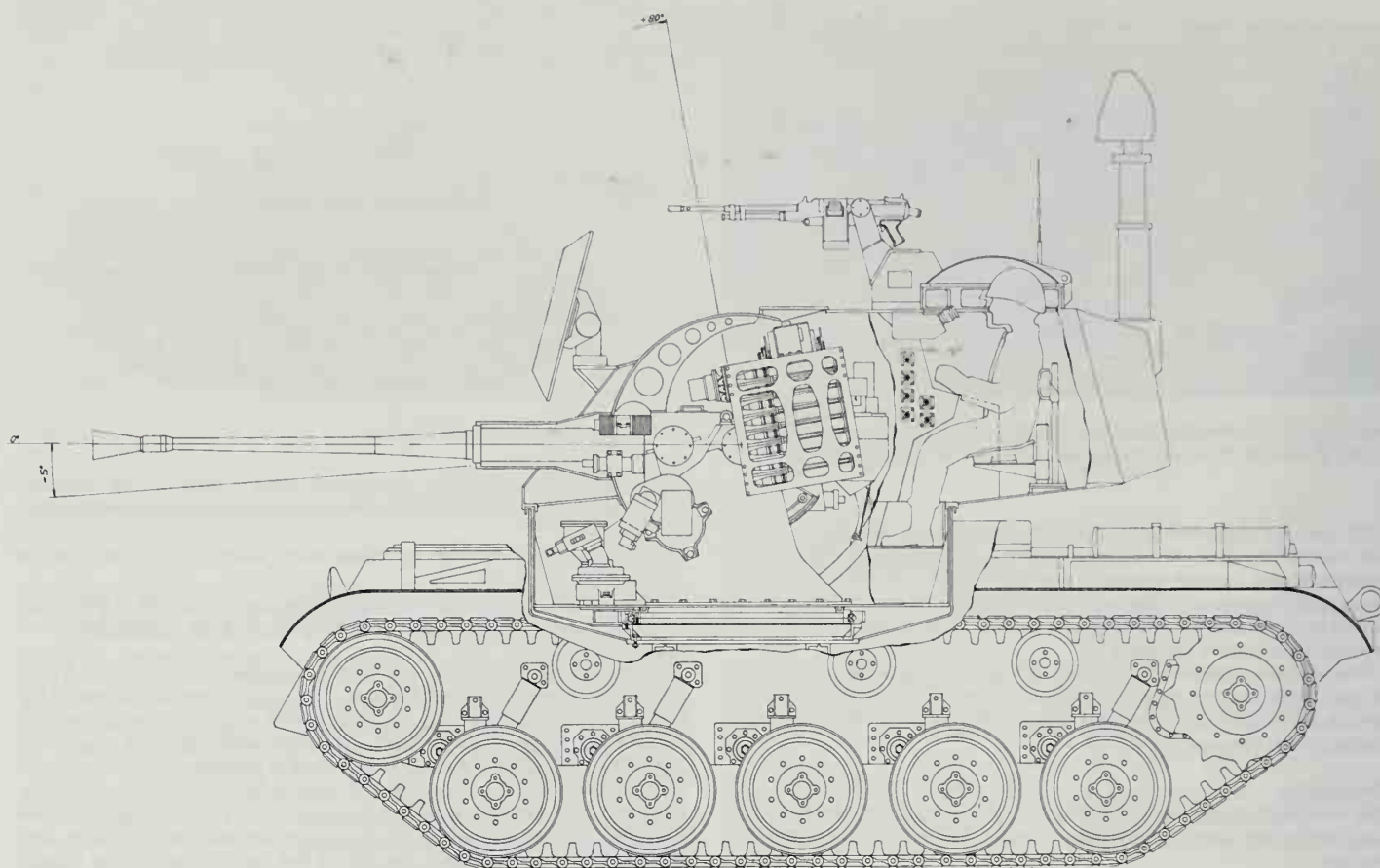
A number of fire control options are available including one with a surveillance radar mounted on the turret rear and the tracking radar mounted to the right of the 40 mm weapon.

#### Variants

In 1982 an M42 was fitted with the same NAPCO powerpack as the M41 light tank but with a modified cooling system. The vehicle was also fitted



M42 twin 40 mm self-propelled anti-aircraft guns showing ready use ammunition stowed on turret rear (US Army)



*Cutaway drawing of an M42 fitted with a new turret by Breda armed with a single 40 mm L/70 gun*

with a Cadillac Gage Textron weapon control system to improve target tracking. Firing trials were undertaken at the US Army Air Defense School at Fort Bliss, Texas. During these the upgraded vehicle successfully shot down one of the target drones engaging it. As of 1991 this improvement package had not been adopted by any country.

Taiwan is known to have refitted several of the M42A2s in service with its army as TOW ATGW vehicles.

#### SPECIFICATIONS

CREW	6
COMBAT WEIGHT	22 452 kg
UNLOADED WEIGHT	20 094 kg
POWER-TO-WEIGHT RATIO	22.26 hp/t
GROUND PRESSURE	0.65 kg/cm <sup>2</sup>
LENGTH GUNS FORWARD	6.356 m
LENGTH HULL	5.819 m
WIDTH	3.225 m
HEIGHT	2.847 m
GROUND CLEARANCE	0.438 m
TRACK	2.602 m
TRACK WIDTH	533 mm
MAX ROAD SPEED	72.4 km/h
FUEL CAPACITY	530 l
MAX ROAD RANGE	161 km
FUEL CONSUMPTION	3.29 l/km
FORDING	1.016 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.711 m
TRENCH	1.828 m
ENGINE	Continental or Lycoming AOS-895-3, 6-cylinder air-cooled super-charged petrol developing 500 bhp at 2800 rpm (M42A1 has AOSI-895-5 with fuel injection which develops the same bhp)
AUXILIARY ENGINE	GMC A41-1 or A41-2
TRANSMISSION	General Motors Allison Division cross-drive model CD-500-3 with one forward and one reverse range
SUSPENSION	torsion bar
ELECTRICAL SYSTEM	24 V

BATTERIES	4 × 12 V, 6TN
ARMAMENT	
main, anti-aircraft	2 × 40 mm cannon
secondary, anti-aircraft	1 × 7.62 mm MG
AMMUNITION	
main, anti-aircraft	480
secondary, anti-aircraft	1750
GUN CONTROL EQUIPMENT	
turret power control	hydraulic/manual
by commander	no
by gunner	yes
max rate power traverse	40°/s
max rate power elevation	25°/s
gun elevation/depression	+85°/(powered) -3° (manual) -5°
turret traverse	360°
ARMOUR	
hull front lower	25.4 mm at 45°
hull front upper	12.7 mm at 33°
hull sides	12.7 mm
hull top	12.7 mm
hull floor	9.05 - 31 mm
hull rear	12.7 mm
turret	9.52 - 15.87 mm

**Status:** Production complete. In service with the following countries:

Country	Quantity	User	Comment
Austria	38	army	
Greece	95	army	from Germany
Guatemala	n/av	army	small number
Jordan	222	army	not all operational
Lebanon	n/av	army	small number
Taiwan	295	army	some being upgraded
Thailand	16	army	
Tunisia	12	army	
Turkey	100	army	from Germany
Venezuela	30	Marine Corps	

**Manufacturers:** Cadillac Motor Car Division of General Motors Corporation, Cleveland Tank Plant.

ACF Industries Incorporated of Berwick, Pennsylvania.



## General Electric Blazer Air Defence Turret

### Development

As a private venture, the Armament Systems Department of GE Aerospace has developed the Blazer air defence turret. The basic turret consists of a 25 mm GAU-12/U Gatling Gun and four General Dynamics Stinger or Matra Mistral fire-and-forget surface-to-air missiles on a two-man turret.

This all-electric turret can be installed on the M2 Bradley chassis, the MOWAG Piranha (8 × 8), the Cadillac Gage V-300 (6 × 6) and the V-150S (4 × 4) vehicles.

Further development of the Blazer turret resulted in the turret system, covered in the following entry, which General Electric developed under contract to the US Marine Corps.

The basic Blazer turret features a digital fire control system, eye-safe laser rangefinder, FLIR/TV stabilised sight and a two-man crew consisting of the commander and gunner. The system can be fitted with the Thomson-CSF TRS 2630 digital radar, the Matra Mistral or Stinger missiles or, as a growth option, command to line-of-sight missiles.

### Description

The Blazer turret is power operated and of all-welded construction with light armour. It can be mounted on any tracked or wheeled vehicle that could accommodate a 1.625 m diameter turret ring. The two-man turret houses both gunner and commander, each capable of full system operation including acquisition, tracking, weapon selection and firing. Vision is through armoured windows on the front and sides.

Main armament of the Blazer turret comprises the GE 25 mm GAU-12/U Gatling gun which fires the Bushmaster family of ammunition at a cyclic rate of fire of 1800 rds/min. The Gatling gun is especially effective in the air defence role due to its high rate of fire. It places a short, dense pattern of projectiles in the path of the target for a high hit probability. According to GE this approach effectively masks the effects on random target motion due to buffeting and jinking. In addition, four or eight infra-red seeker missiles are mounted above the gun cradle and integrated into the Blazer's fire control system. Command guided missiles such as Starstreak can also be fitted effectively due to the system's pointing accuracy.

A FLIR/TV sight is included for viewing and auto-tracking. The system has demonstrated day/night capability and the ability to track and fire while the vehicle is moving at up to 50 km/h over uneven terrain. In 1985 testing in the US, both gun and missile kills were recorded under such conditions with a prototype system.

The Thomson-CSF TRS 2630 2D radar has a range of 17 km, IFF, automatic track-while-scan and data exchange for netting capability. The latter feature allows one system to act as a command unit for several units without operating acquisition sensors. The 25 mm cannon can engage targets up to 2500 m and the missiles at 6000 m. A total of 400 ready rounds are in the magazine, with up to 600 stowed rounds in the vehicle. Internal loading of the 25 mm gun could be accomplished in 15 minutes. Depending on the chassis, additional missiles can be stored internally. Electronically operated smoke dischargers are located in banks of four on either side of the turret.



LAV (8 × 8) fitted with General Electric Blazer air defence turret armed 25 mm cannon and three Mistral SAMs with Thomson-CSF TRS 2630 radar mounted on side of turret roof

### SPECIFICATIONS

CREW	2 (commander/gunner)
ARMAMENT	25 mm 5 barrel GAU-12/U 4 or 8 fire-and-forget SAM (Stinger, Mistral)
TRAVERSE	360°
ELEVATION/DEPRESSION	+65°/-8°
SIGHT	FLIR/TV and eye-safe laser rangefinder
FIRE CONTROL	digital, full fire-on-the-move solution
SENSORS	temperature, pressure, wind and vehicle tilt, Thomson-CSF TRS 2630 acquisition radar

**Status:** Pre-production prototype.

**Manufacture:** GE Aerospace, Armament Systems Department, Lakeside Avenue, Burlington, Vermont 05401-4935, USA.

Telephone: (802) 657 4985

Telex: 510 2990 028

Fax: (802) 657 7493

## Light Armored Vehicle (LAV) Air Defense

### Development

At the present time the US Marine Corps has no mobile battlefield air defence weapons and relies on the manportable General Dynamics Stinger and towed Raytheon Improved HAWK SAMs to meet its air defence requirements, although it is expected to procure the Pedestal Mounted Stinger (PMS) system from Boeing which won the US Army competition as part of the FAADS programme in 1987.

Before deciding on a gun/missile/rocket hybrid system, the Marine Corps evaluated five possible solutions to meet the LAV-AD requirements. These were:

- (1) a baseline system consisting of a standard LAV-25 equipped with the McDonnell Douglas Helicopters 25 mm Chain Gun and carrying two 2-man Stinger SAM teams
- (2) basic LAV-25 modified to carry Stinger SAM pods and equipped with a narrow field-of-view FLIR system
- (3) LAV with new turret mounting for British Aerospace Rapier SAMs and a millimetre wave radar
- (4) LAV with Oerlikon-Contraves ADATS which at that time had not been adopted by the US Army
- (5) LAV with General Electric GAU-12/U 25 mm Gatling gun, Stingers and HYDRA-70 rockets with growth potential.

In May 1987 the US Army Tank Automotive Command (TACOM) solicited bids from 75 companies for an air defence version of the Light Armored Vehicle (LAV), but only two bids were received, one from FMC Corporation and the other from the General Electric Company.

In December 1987 the FMC Corporation was awarded an initial contract worth \$8.916 million while General Electric was awarded a contract worth \$6.718 million. Total cost of building the four prototypes is expected to be \$49 million.

Each company has built two prototypes based on the Light Armored Vehicle (8 × 8) chassis which has been provided by the Marine Corps and these commenced trials in August 1990. Following firm production proposals from the two manufacturers it is anticipated that a firm production order will be placed in the first quarter of 1992. It was expected that production LAV-AD would be built on existing LAV (8 × 8) chassis but it is now expected to be a new build.

The weapon system selected will be capable of being upgraded with future air defence missiles using command to line-of-sight guidance.

The main role of the LAV-AD is to engage fixed-wing aircraft and helicopters with a secondary role to engage ground targets using its cannon and HYDRA-70 rockets which are already fired by US Marine Corps helicopters.

Typically the Stingers would be used to engage targets out to 6000 m with the cannon engaging targets out to 2000/2500 m. The HYDRA-70 rockets can be used both in ground/ground and ground/air roles and have a range of up to 8000 m. In the ground/air role they would be used to engage hovering helicopters.

Although the prototype systems had a single pod of four Stinger SAMs and a pod of seven HYDRA 70 rockets, it is expected that production systems will have two pods each of four Stingers with the HYDRA 70 rocket pod being optional.



*One of the prototypes of the FMC Light Armored Vehicle-Air Defense*



*One of the prototypes of the General Electric Light Armored Vehicle-Air Defense*

The US Marine Corps Requirement is for a total of 125 vehicles with the original intention being to utilise chassis already built for other applications. Total cost of the 125 production LAV-AD has been estimated at \$507 million. Each of the three active Marine Amphibious Forces will have 24 vehicles with a further 12 vehicles being allocated to the Marine Corps 4th Marine Division.

The US Marine Corps has already received 758 LAVs in six configurations from the Diesel Division, General Motors of Canada, with final deliveries made in 1988.

The LAV-AD will be fully airtransportable being slung under the Sikorsky CH-53E heavy-lift helicopter and like other members of the LAV family will be fully amphibious as it is propelled in the water by two propellers mounted at the rear of the hull. It will also be air transportable in a Lockheed C-130 and large-size transport aircraft.

#### **Description**

Both versions use a modified LAV (8 × 8) chassis in which the driver is seated at the front left with engine compartment to his right and the remainder of the hull free for the turret and ammunition stowage. The commander and gunner can enter the vehicle through the turret and via the twin doors at the rear of the hull.

#### **FMC LAV-AD**

The FMC version of the LAV has a two-man power operated turret armed with a pod of four General Dynamics Stinger SAMs in the ready-to-launch position at left rear; a McDonnell Douglas Helicopters dual feed M242 25 mm Chain Gun with a high rate of fire in the centre of the turret and above this are two pods of HYDRA-70 (2.75 in) rockets, each with seven rockets in the ready-to-launch position. The rockets can be fitted with a wide range of warheads.

Cadillac Gage Textron provide the electric turret controls with turret traverse a full 360° and weapon elevation from -8 to +65°.

The M242 25 mm Chain Gun is already in service with the US Marine Corps and is installed on LAV-25 (8 × 8) vehicles.

Mounted on the turret rear is the fire control system which includes a primary sight with two fields-of-view, FLIR and TV, auto-tracker, eye-safe laser rangefinder and two video displays. Backup sights are also fitted.

The four round Stinger launcher, 25 mm Chain Gun and two pods of HYDRA rockets are mounted on a common rotor. Total ammunition supply will consist of 12 Stinger missiles, 990 rounds of 25 mm, 14 HYDRA rockets and 16 smoke grenades.

The FLIR magnification is × 8 and × 2.67 while the day TV is × 12 and × 4. In addition there are two backup sights boresighted to the weapons. Sensors include dual axis wind, pressure, temperature, pitch and cant. The vehicle is also fitted with a land navigation system. Total weight of the LAV turret is projected to be 3091 kg complete with ammunition and two-man crew.

It is expected that production LAV-AD will have two pods of four Stinger SAMs with the pod of HYDRA rockets being omitted.

#### **General Electric LAV-AD**

The General Electric system is based on the company's private venture Blazer two-man power operated turret covered in the previous entry and is armed with the GAU-12/U 25 mm Gatling Gun, four or eight Stinger surface-to-air missiles. The 25 mm GAU-12/U is already used by the Marine Corps McDonnell Douglas AV-8B ground attack aircraft.

In addition to the four missiles in the ready-to-launch position, each version carries a further eight missiles in reserve which are loaded manually. A standard Stinger gripstock is also carried so that missiles can be deployed away from the vehicle if required by the tactical situation. Each version also has a 7.62 mm machine gun for local protection and two banks of four electrically operated smoke dischargers.

Combat weight of the LAV-AD, complete with crew and ammunition is estimated to be 13 182 kg. Turret traverse is powered to 360° with powered weapon elevation from -8 to +65°. It will have a fire on the move capability with sensors including temperature, pressure, wind and vehicle tilt.

**Status:** Four prototypes, two from FMC Corporation and two from the General Electric Company, were delivered to the US Marine Corps for trials early in 1990. A production decision for the LAV-AD is expected in the first quarter of 1992.

**Manufacturers:** FMC Corporation, Ground Systems Division, 1105 Coleman Avenue, San Jose, California 95108, USA.

Telephone: (408) 289 3960

Telex: 34 6462

General Electric Company, Armament Systems Department, Lakeside Avenue, Burlington, Vermont 05401 4985, USA.

Telephone: (802) 657 4985

Telex: (510) 299 028

Fax: (802) 657 7493



## General Electric M163 20 mm Vulcan Self-propelled Anti-aircraft Gun System

### Development

Development of the Vulcan air defence system began under the direction of the United States Army Weapons Command at Rock Island Arsenal, Illinois, in 1964. Two versions of the Vulcan were subsequently developed, a self-propelled model called the M163 (development designation XM163) and a towed model called the M167 (development designation XM167). Prime contractor for both models is the Armament Systems Department of the General Electric Company of Burlington, Vermont.

After trials carried out by the United States Army Air Defense Board at Fort Bliss, Texas, and at Aberdeen Proving Ground, Maryland, in 1965, the system was accepted for service in that year as the replacement for the twin 40 mm M42 self-propelled anti-aircraft gun. First production M163s were delivered to the United States Army in August 1968 and final deliveries were made in 1970. Since then the system has been placed back in production for export during 1975-79 and briefly again in 1982 before finally closing down. Israel used the system during the 1982 invasion of Lebanon when it destroyed several Syrian aircraft, including one Sukhoi Su-7 fighter-bomber and several 'Gazelle' ATGW helicopters. The Israelis have also developed the M163 for use in the ground defence role in support of the Infantry.

The M163 is deployed with the United States Army in composite battalions with the Chaparral low altitude surface-to-air missile system. This battalion has 24 Chaparral systems (two batteries each with 12 launchers) and 24 M163s (two batteries with 12 each). Early warning for the M163 batteries is provided by the Sanders Associates Forward Area Alerting Radar model AN/MPQ-49. By early 1987 a total of 671 M163 systems had been built, of which 601 were for the US Army and 70 for export. However, a considerable number of US Army vehicles have been diverted to foreign users since a total of 292 vehicles (including the 70 export) have been sold under the FMS programme. This leaves 389 in US Army service which is close to the 1981 inventory total of 379 M163A1s.

By mid-1991 the US Army had withdrawn all of its M163 Vulcan air defence systems deployed in Europe and also planned to withdraw the other systems remaining in service in the United States and South Korea.

Reasons cited for the withdrawal included high costs of operating and maintaining the system, limited effectiveness of its 20 mm Vulcan cannon, lack of armour and lack of cross-country mobility with the systems that it is designed to protect.

### Description

The M163 basically consists of an M113A1 APC fitted with a one-man electrically driven turret which has a 20 mm Vulcan cannon, Navy Mk 20 Mod 0 gyro lead-computing sight and an EMTECH range-only radar mounted on the right side of the turret. The chassis, which is designated the M741, differs from the M113A1's in minor details only, including the provision of a suspension lock-out system to provide a more stable firing platform when the weapon is being fired, the installation of buoyant pods on either side of the hull and a buoyant trim vane at the front of the hull to improve its amphibious characteristics and an additional circular hatch cover in the hull roof on the right side. The 20 mm six-barrelled M168 cannon is a development of the weapon originally developed for aircraft such as the



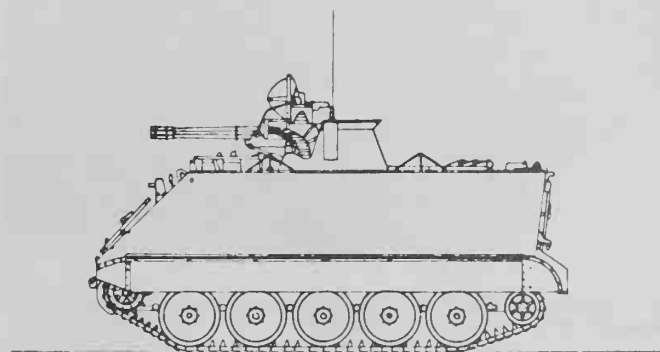
M163A1 Vulcan self-propelled air defence system fitted with Product Improved Vulcan Air Defense System (PIVADS)

Lockheed F-104 Starfighter and has two rates of fire; 1000 and 3000 rds/min. The original version fired up to 6000 rds/min. The 1000 rds/min rate is normally used in the ground role and the 3000 rds/min rate in anti-aircraft defence. Maximum effective anti-aircraft range is 1200 m, ground range 3000 m and indirect fire range 4500 m. The kill probability per engagement of the basic system is quoted as 0.35 against targets with velocities between 0 and 450 knots.

The weapon has an elevation of +80°, depression of -5° and 360° turret traverse. The gunner can select either 10-, 30-, 60- or 100-round bursts. The dispersion pattern can be increased by fitting a special muzzle adaptor, which causes the pattern to be spread, resulting in an increased hit probability. The linkless ammunition feed system in the M163 carries 1180 rounds ready to fire and an additional 1100 rounds in reserve inside the hull. Rows of ammunition are held in the feed drum in lateral tracks. A helix mounted in the centre of the drum moves ammunition along the tracks to the exit-port of the drum. The ammunition is carried from the feed drum to the gun feeder through conveyor chuting. The turret drive is controlled by solid-state, rate servo-amplifiers, one for elevation and two for azimuth. These servo-amplifiers are interchangeable in function, as are the drive motors they control. Power for the system is provided by three 24-volt nickel-cadmium batteries, two of which drive the Vulcan cannon and the third drives the turret. The batteries are charged either by the vehicle



US Army M163 20 mm self-propelled anti-aircraft gun system with all hatches closed



M163 Vulcan self-propelled anti-aircraft gun

generator or an APU. Fire control for the system consists of a gyro lead-computing gunsight, a sight current generator and an EMTECH AN/VPS-2 fully coherent I-band pulse Doppler range-only radar with target track range limits of 250 to 5000 m. The gunner visually acquires and tracks the target with the gyro lead-computing gunsight. The antenna axis of the radar is servoed to the optical line-of-sight. The radar supplies target range and range-rate data to the sight generator. With range, range-rate, and angular tracking of the optical line-of-sight (measured by a freely gimbaled gyro), the sight automatically computes the future target position and adds the required super-elevation to hit the target. The lead angle is equal to the angular rate of the target multiplied by the time of flight of the projectile to the future target position. Turret fire control is a disturbed line-of-sight system. The sight case and gun bore are physically fixed in alignment. The sight graticule, which defines the optical line-of-sight, is positioned by the gyro and is displaced from the gun bore as the gunner tracks the target, thereby establishing the proper lead angle. The amount of optical line-of-sight displacement is dependent on the range and range rate inputs to the sight. The required tracking time to establish the lead angle is about one second. A green light appears in the sight optics signalling that the radar has acquired the target and that the target is within the effective range of the turret system. In the manual mode the gunner must estimate target range and speed and set the estimates on indicator dials on the control panel. The gyro lead-computing gunsight then computes the lead angle based on these estimates.

The 20 mm M168 cannon can fire the following types of fixed ammunition: M53 (APT) with the projectile weighing 0.1 kg and a muzzle velocity of 1030 m/s  
M54 (HPT) with the projectile weighing 0.127 kg  
M55A2 (TP) with the projectile weighing 0.098 kg and a muzzle velocity of 1030 m/s  
M56A3 (HEI) with the projectile weighing 0.103 kg and a muzzle velocity of 1030 m/s  
M220 (TPT) with the projectile weighing 0.097 kg and a muzzle velocity of 1030 m/s  
M242 (HEIT) with the projectile weighing 0.094 kg and a muzzle velocity of 1030 m/s.  
Reload time is five minutes.

#### Variants

#### Stinger in M163A1

In 1988 it was stated that a Stinger gunner would be the fourth member of Vulcan SPAAG crew replacing the crew member who had observer duties. A total of two Stinger SAMs will be carried inside the vehicle.

#### Product Improved Vulcan Air Defense System (PIVADS)

General Electric has modified the fire control system of the current Vulcan Air Defense System family and incorporated the ability to fire a new Mk 149 APDS round which increases the effective range of the system to 2600 m. The fire control improvements include replacing the disturbed line-of-sight currently used with a director sight to give a rate-aided tracking capability and linking a digital fire control computer to the range-only radar for more

accurate lead and superelevation commands to the cannon. The net result of the programme is to increase effectiveness while greatly simplifying the operation. The PIVADS programme is available in the form of modification kits for both the towed and self-propelled Vulcan air defence systems. In September 1982 the US Army awarded Lockheed Electronics a contract for 285 kits for both the towed and self-propelled versions of the 20 mm Vulcan air defence systems with first deliveries made in June 1984. These are being installed on towed and self-propelled Vulcan air defence systems with final deliveries in 1988. In 1990 all manufacturing pertaining to this system was transferred to Lockheed Canada Inc in Ottawa, Ontario. The company, a part of the Lockheed Electronics Group, was then awarded its first PIVADS contract for \$4.2 million to supply spares to the US Army.

#### SPECIFICATIONS

CREW	4
COMBAT WEIGHT	12 310 kg
POWER-TO-WEIGHT RATIO	17.46 bhp/t
GROUND PRESSURE	0.61 kg/cm <sup>2</sup>
LENGTH	4.86 m
WIDTH	
overall	2.85 m
reduced	2.54 m
HEIGHT	
including turret	2.736 m
to top of driver's hatch periscope	2.07 m
to hull top	1.83 m
GROUND CLEARANCE	0.406 m
TRACK	2.159 m
TRACK WIDTH	381 mm
LENGTH OF TRACK ON GROUND	2.667 m
MAX SPEED	
road	67.59 km/h
road, on 10% gradient	18.7 km/h
water	5.6 km/h
FUEL CAPACITY	360 l
MAX RANGE	483 km
FORDING	amphibious
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.61 m
TRENCH	1.68 m
ENGINE	Detroit Diesel model 6V-53 6-cylinder water-cooled diesel developing 215 bhp at 2800 rpm Allison TX-100 consisting of 3-speed gearbox and 2-stage torque converter giving 6 forward and 2 reverse gears
TRANSMISSION	torsion bar
SUSPENSION	24 V
ELECTRICAL SYSTEM	1 x 6-barrel 20 mm cannon
ARMAMENT (main)	none
SMOKE-LAYING EQUIPMENT	2280
AMMUNITION	
GUN CONTROL EQUIPMENT	
turret power control	electric/manual
by commander	no
by gunner	yes
max rate power traverse	60°/s
max rate power elevation	45°/s
gun elevation/depression	+80°/-5°
turret traverse	360°
ARMOUR	12-38 mm

**Status:** Production complete. In service with the following countries:

Country	Quantity	User	Comment
Israel	46	air force	delivered in 1970s
Jordan	100	army	delivered 1976 to 1978
Morocco	60	army	
Portugal	36	army	
Sudan	8	army	delivered 1982
Thailand	24	army	
USA	360	army	being phased out of service
Yemen	20	army	

**Manufacturer:** General Electric Company, Armament Systems Department, Lakeside Avenue, Burlington, Vermont 05401 4985, USA.  
Telephone: (802) 657 4985  
Telex: (510) 299 028  
Fax: (802) 657 7493  
(Carrier provided by FMC Corporation and radar by Lockheed Electronics.)



US Army 20 mm M163A1 Vulcan air defence system from the rear showing extensive external stowage (C R Zwart)



## General Electric Vulcan-Commando 20 mm Self-propelled Air Defense System

### Development

The Vulcan-Commando air defence system is an outgrowth of a requirement generated by Saudi Arabia. The 20 mm Vulcan turret used is designed as a 'drop-in' installation, requiring only correct location of mounting holes in the vehicle hull, while remaining operationally independent of the vehicle. The basic Vulcan air defence system turret (without radar) can be used as an alternative installation. Future production systems would be based on the new Commando V-150 S (4 × 4) chassis.

### Description

The Vulcan-Commando system uses the same turret, weapon and associated feed, power and radar equipment as the M163 Vulcan air

defence system. The vehicle used is the Cadillac Gage Commando V-150 fitted with three hydraulic stabilising jacks controlled from inside the vehicle. The system has four operational modes: (a) Radar, which is the most accurate of the three anti-aircraft engagement modes. The radar supplies continuous range and range rate information to the system's analogue computer so that computations for the gyro lead sight can be made (b) Manual, in which the gunner estimates the engagement range and target speed and then manually enters them on the control panel (c) External, in which a second person off-mount estimates the target's range and enters the data on a hand-held potentiometer connected to the fire control system by a cable and (d) Ground, in which the gyro sight is not operated and the lead angle not computed. The sight is mechanically caged at zero lead angle and 7 mils of superelevation.

The vehicle has a crew of four; driver, gunner, commander and radio operator.

### SPECIFICATIONS

CREW	4
CONFIGURATION	4 × 4
COMBAT WEIGHT	10 206 kg
LENGTH	5.689 m
WIDTH	2.26 m
HEIGHT (to hull top)	1.981 m
WHEELBASE	2.667 m
MAX SPEED	
road	88.54 km/h
water	4.828 km/h
FORDING	amphibious
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.914 m
TURNING RADIUS	8.382 m
ENGINE	V-8 diesel developing 202 bhp at 3300 rpm
TRANSMISSION	automatic
ARMAMENT	1 × 6-barrel 20 mm cannon
AMMUNITION	1300

**Status:** Production as required. A total of 20 systems were delivered to the Saudi Arabian National Guard.

**Manufacturer:** General Electric Company, Armament Systems Department, Lakeside Avenue, Burlington, Vermont 05401 4985, USA.

Telephone: (802) 657 4985

Telex: (510) 299 028

Fax: (802) 657 7493

(Chassis provided by Cadillac Gage Textron, Warren, Michigan).



*Vulcan-Commando self-propelled anti-aircraft system with turret traversed to left and 20 mm cannon firing*

## YUGOSLAVIA

### BOV-3 Triple 20 mm Self-propelled Anti-aircraft Gun System

#### Development

The BOV-3 self-propelled anti-aircraft gun system is part of an indigenously designed family of wheeled armoured vehicles and was shown officially for the first time at the 1984 Cairo Defence Exhibition.

#### Description

The hull of the BOV-3 is of all-welded steel construction. The driver sits at the front left and the commander to his right, both with a rear-opening single-piece hatch cover. The driver has three periscopes for forward observation and a single vision block and firing port in the left side of the hull; the commander has a single forward-facing periscope. There is a crew entry hatch in the left side of the hull and a single roof hatch to the rear of the driver. The other two crew members, the gunner and loader, normally sit inside the vehicle when not manning the anti-aircraft weapons.

The engine compartment is at the rear of the hull with air-inlet and air-outlet louvers on the top and an engine access door at the rear. It also contains the air filters, heating device, fuel piping and control mechanism. The vehicle is powered by a German Deutz type F 6L 413 F six-cylinder diesel developing 148 hp at 2650 rpm. This is coupled to a manual gearbox with five forward and one reverse gears and a two-speed transfer case. Two hatches in the roof and the rear access door allow access for servicing of the engine and other systems. Steering is power assisted to reduce driver fatigue and a central tyre-pressure system is fitted as standard, pressure can be adjusted from 0.7 to 3.5 bars to suit the ground being crossed. The main brakes are air-hydraulic dual circuit with a hand-operated



*BOV-3 20 mm self-propelled anti-aircraft gun system showing climbing capability*

parking brake. Suspension consists of leaf type springs with telescopic shock absorbers with 1300 - 18 PR10 cross-country tyres fitted as standard. The differential locks are controlled electropneumatically.

Standard equipment includes a Jugo-Webasto 7.5 kW heater, day and infra-red night vision equipment, intercom and radios.

Mounted in the centre of the roof is the open-topped turret with an external turret basket at the rear. Access to the turret is only from outside of the vehicle with extension pieces provided on the hull top either side of the turret for reloading.

The turret is based on the standard towed 20/3 mm gun M55 A4 B1 which has been in service with the Yugoslavian Army for some years. The turret has full 360° hydraulic traverse at a speed of 80°/s with an acceleration of 120°/s<sup>2</sup>. Weapon elevation is from -4.5 to +83° at 50° with an acceleration of 60°/s<sup>2</sup>.

TYPE	HEI-T	HE-T	HEI	HE	API	API-T	AP-T
DESIGNATION	M57	M57	M57	M57	M60	M60	M60
WEIGHT OF PROJECTILE	137 g	137 g	132 g	132 g	142 g	142 g	142 g
TYPE OF BURSTING CHARGE	TNT or RDX/Alum	TNT or RDX/Alum	TNT + Inc	TNT or RDX/Alum	nil	nil	nil
TOTAL WEIGHT OF ROUND	261 g	261 g	257 g	257 g	274 g	274 g	274 g
MUZZLE VELOCITY	850 m/s	850 m/s	850 m/s	850 m/s	840 m/s	840 m/s	840 m/s

Additional rounds include TP-T (M57), TP (M57), Blank (M77) and drill.

All of the above have brass cartridge cases 110 mm long with propellant being NC powder.

Maximum anti-aircraft engagement altitude is quoted as 2000 m although effective anti-aircraft range is between 1000 and 1500 m. The weapons can also be used in the direct fire support role against ground targets when the maximum range is approximately 2000 m.

The triple 20 mm cannon are aimed via a J-171 sight mounted to the rear of the gun shield. The gunner has a joystick to control elevation and traverse and a foot pedal for firing the cannon. The BOV-3 is a clear weather system only with no provision for external fire control, although general warning of targets approaching could be given over the radio net.

#### Variants

The BOV-3 20 mm self-propelled anti-aircraft gun system is a member of the BOV 4 × 4 series of wheeled light armoured vehicles. These include the BOV-1 anti-tank vehicle armed with the Sagger ATGW and the BOV-M armoured personnel carrier. In 1985 the BOV-30 self-propelled anti-aircraft gun system was revealed. This uses the chassis of the BOV-3 but with a smaller, upright turret with the gunner seated in a raised cupola at the rear and is armed with two externally mounted 30 mm cannon. The turret has a

Each of the three 20 mm barrels has a drum-type magazine holding 60 rounds of ammunition with an external indicator showing how many rounds are available (10, 30, 40, 50, 60). The weapons have a cyclic rate of fire of 750 rds/barrel/min and the gunner, seated at the turret rear, can select either single shots, bursts of 10 rounds, bursts of 10 to 20 rounds or sustained fire. A total of 1500 rounds of ammunition is carried, which, apart from the three ready use drums in the turret, is stowed internally on special racks for quick access. Ammunition types that can be fired include:-

rate of fire of 1200 rds/min. Three grenade launchers are attached to each side of the turret for smoke rounds.

#### SPECIFICATIONS (BOV-3)

CREW	4
CONFIGURATION	4 × 4
COMBAT WEIGHT	9400 kg
POWER-TO-WEIGHT RATIO	15.74 hp/t
LENGTH	5.791 m
WIDTH	2.525 m
HEIGHT	3.21 m
GROUND CLEARANCE	0.325 m
TRACK	1.9 m
WHEELBASE	2.75 m
MAX ROAD SPEED	93.4 km/h
RANGE	500 km
FORDING	1.1 m
GRADIENT	55%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.54 m
TRENCH	0.64 m
TURNING RADIUS	7.75 m
ENGINE	Deutz type F 6L 413 F 6-cylinder diesel developing 148 hp at 2650 rpm
TRANSMISSION	manual, 5 forward and 1 reverse gears
SUSPENSION	leaf springs and hydraulic shock absorbers
ELECTRICAL SYSTEM	24 V
BATTERIES	2 × 12 V, 143 Ah
ARMAMENT	3 × 20 mm cannon
TURRET TRAVERSE	360°, powered/manual
ELEVATION/DEPRESSION	+83°/-4.5°
AMMUNITION	1500 × 20 mm
SMOKE DISCHARGERS	yes

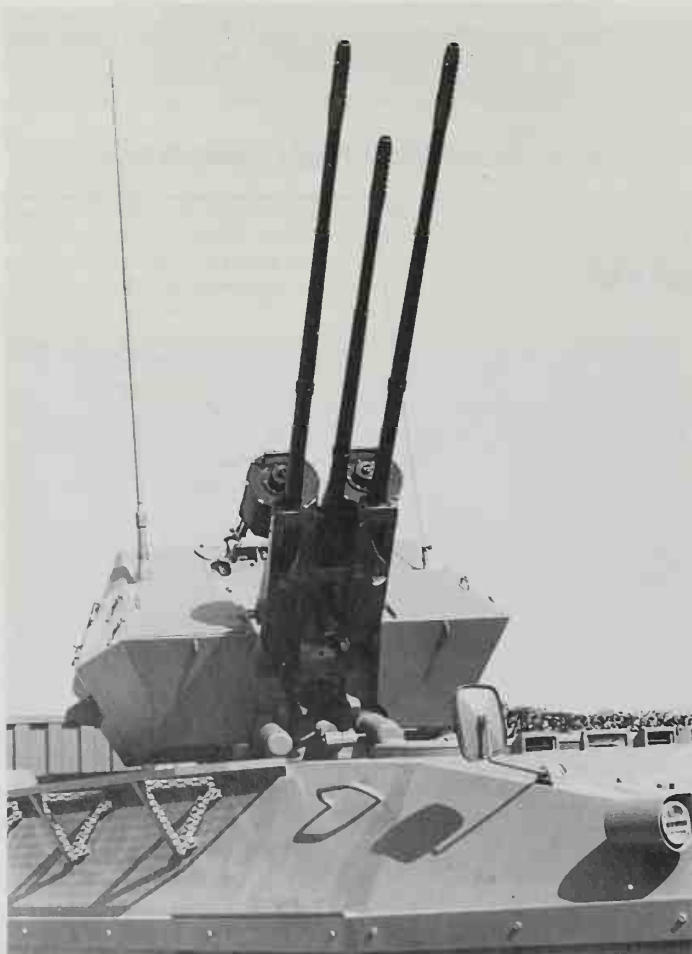
**Status:** In production. In service with the Yugoslavian Army.

**Contractor:** SDPR - Federal Directorate of Supply and Procurement, PO Box 308, 9 Nemanjina Street, Yu-11005 Beograd, Yugoslavia.

Telephone: 621 522

Telex: 11360

Fax: 38 11 635 702



Close up of BOV-3 triple 20 mm self-propelled anti-aircraft gun turret (Christopher F Foss)



BOV-30 twin 30 mm self-propelled anti-aircraft guns in travelling configuration with hatches open



# Self-Propelled Surface-to-Air Missiles

## BRAZIL

### AVIBRAS MAC-MP Low Altitude Anti-Helicopter Missile System

#### Development/Description

The Brazilian missile and rocket manufacturer AVIBRAS is developing a dual-purpose fibre optic guided anti-tank and low altitude anti-helicopter missile known as the MAC-MP. Initial prototype flight trials took place between January and May 1989.

The launcher assembly is of modular construction with the customer choosing the number of ready to fire missile container-launcher packs. Both they and the missile control ground station unit can be transported on a variety of vehicle types such as a  $\frac{3}{4}$  ton  $4 \times 4$  light truck (which can carry up to eight missiles) or a heavier vehicle (which can carry up to 16 missiles). The only major difference in the two layouts being that on the lighter vehicle the missile containers would be carried horizontally and elevated for firing. Only two system operators are required, and it is possible to reload them at the firing site.

Launch weight is 33 kg with the missile being boosted out of its container by a small solid propellant rocket section mounted at the rear. The main solid propellant sustainer rocket motor then takes over with its exhaust being ejected through two outlets on either side of the missile. Flight control is achieved by four movable pop-out wings at the front of the missile while stabilisation is assured by four pop-out fixed fins at the rear.

Once launched the missile's Optolaser TV seeker head transmits video images, back to the ground station, of the terrain overflown via the Fibras

Opticas fibre optic wire link. Target selection is made by the gunner on the basis of his evaluation of the imagery received. He also guides the weapon via command signals sent to the missile's guidance package over the same data link. The signals are then translated into control movements for the wings.

Line-of-sight to a target need not be maintained or even be obtained after launch as the gunner can either take cover, or use the missile in its indirect fire mode. In both cases he utilises the seeker head video to obtain the target position. The missile's slow flight speed allows him the time needed to detect, select, acquire and attack a suitable target.

Cruise altitude of the missile is 200 m and maximum engagement range 10 000 m. For a target at ground or very low level, the gunner commands the weapon to perform a terminal vertical top attack dive onto the most vulnerable spot visible. The warhead carried is of the tandem HEAT type and is capable of penetrating more than 1000 mm of steel armour plate.

**Status:** Under development, not yet in production or service.

**Manufacturer:** AVIBRAS INDÚSTRIA AEROSPACIAL SA, Marketing Division, Rodovia dos Tamoios, KM14M, PO Box 278 12300 Jacaref, São Paulo, Brazil.

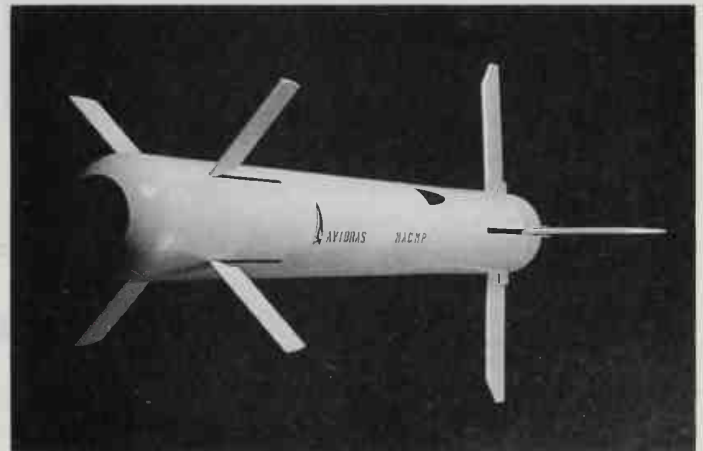
Telephone: (55-123) 51 6637

Telex: (123) 3493 AIAE BR

Fax: (55-123) 516048/516706



One of the prototypes of the AVIBRAS MAC-MP missile shortly after launch



AVIBRAS MAC-MP missile with four movable pop-out wings at the front and four pop-out fixed fins at the rear

## CHINA, PEOPLE'S REPUBLIC

### NORINCO PL-9 Low Altitude Surface-to-air Missile System

#### Development/Description

This low altitude SAM system was first displayed in model form at the 1989 Paris Air Show. It comprises a four-rail launcher assembly cupola for PL-9 missiles and associated target acquisition radar and electro-optical instruments mounted on the rear decking of a NORINCO WZ 551D (6 x 6) APC.

The launcher can also be refitted to fire other types of surface-to-air or modified air-to-air missiles of similar configuration to the PL-9, according to the customer's requirements.

Each WZ 551D carries two vehicle drivers, three system operators and four ready to fire PL-9 missiles. The target acquisition radar has a detection range of around 18 000 m and an altitude capability up to 6000 m. The passive electro-optical target sighting/tracking system with TV monitor has an operational range of 15 000 m and a laser rangefinder unit with a 10 000 m range capability.

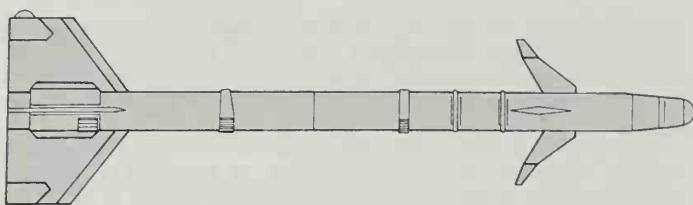
The vehicle troop compartment is fitted with the system fire control computer, the operator's launch and fire control console with visual displays for the radar and electro-optical sensors and the servo mechanisms for controlling the launch cupola in azimuth and elevation.

A WZ 551D unit requires the following technical service facilities:

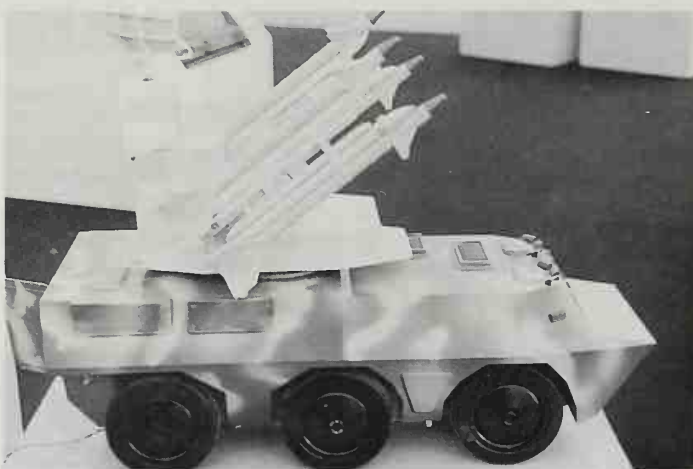
- (a) missile test equipment on launch vehicles
- (b) missile test equipment at technical battery site

- (c) launcher test equipment
- (d) missile transloader vehicles for resupply
- (e) a cryogenic gas recharge carrier vehicle
- (f) a test and maintenance vehicle for the fire unit launcher assemblies.

The missile used is the dual purpose PL-9 air-to-air and ground-to-air passive infra-red terminal homing weapon which appears to be roughly similar in physical appearance to the American AIM-9L Sidewinder air-to-air missile. It is capable of off-axis launch and uses an all-aspects cryogenic liquid nitrogen gas-cooled seeker head unit which utilises proportional navigation guidance techniques. Flight control is by long span pointed delta fins at the front of the missile with Sidewinder-type slipstream driven



Scale drawing of the PL-9 surface-to-air missile (not to 1/76th scale)



Scale model of the NORINCO PL-9 low altitude surface-to-air missile system on a WZ 551D (6 × 6) armoured personnel carrier (Terry J Gander)

'rolleron' on the aft tail fin surfaces to prevent roll and so enhance the operation of the guidance system.

Missile length is 2.994 m, it has a diameter of 0.16 m and wing span of 0.808 m. Launch weight is 120 kg with a 10 kg HE fragmentation warhead. Maximum speed is Mach 2.0 with a maximum engagement range of 8500 m at targets up to 5000 m in altitude. Maximum effective range is 5500 m at targets up to the same altitude limit. The Single Shot Kill Probability (SSKP) for a single missile launch at an approaching target is 0.8.

The PL-9 surface-to-air missile is also used in the Brigade (Regiment) Level 390 Integrated Gun-Missile Air-Defence System.

#### SPECIFICATIONS (WZ 551D APC)

CREW	5
CONFIGURATION	6 × 6
COMBAT WEIGHT	about 16 000 kg
LENGTH	6.65 m
WIDTH	2.8 m
HEIGHT	
combat state	5 m
travelling (radar down)	3.4 m
GROUND CLEARANCE	0.41 m
TRACK	2.44 m
WHEELBASE	1.9 m + 1.9 m
ENGINE	Deutz F8L 413F 4-cycle air-cooled diesel developing 256 hp at 2500 rpm
TRANSMISSION	manual, 9 forward and 1 reverse gears
STEERING	hydraulic first and second axles
SUSPENSION	coil springs and hydraulic shock absorbers
TYRES	14.00 × 20 (run flat)
BRAKES	dual circuit, air/hydraulic
ELECTRICAL SYSTEM	27 V DC
ARMAMENT	four rail launcher with PL-9 missiles (no reloads)
LAUNCHER ASSEMBLY	
traverse	360°
angular velocity	60°/s
elevation	-5 to +80°
angular velocity	45°/s

Status: Development.

**Manufacturer:** Enquiries to China North Industries Corporation, 7A Yue Nan Jie, PO Box 2137, Beijing, People's Republic of China.

Telephone: (86) 7840/3392

Cable: NORINCO Beijing

Telex: 22339 CNIC CN

## FRANCE

### Thomson-CSF Mygale Air Defence System

#### Development/Description

The Thomson-CSF Mygale is designed to be fully co-ordinated Very Short Range Air Defence System (VSHORADS) for use in defence of Vital Points or military units.

A typical Mygale platoon consists of two components:

- (a) an air defence command and control post known as Samantha or (in its modular form) as Mantha. The command post carries out the main functions of air space monitoring by using a pulse Doppler frequency agile radar for surveillance, target acquisition and identification duties in order to attain the threat assessment and target designation requirements for its firing post co-ordination and control role. It also provides the data link interface necessary for integration of the Mygale platoon into tactical air defence networks.

The radar used in the French Army and export versions of the post is the Thomson-CSF 2D solid-state 2630P model. It is mounted on a hydraulic mast for raising above the carrier vehicle when stationary so as to improve the low level detection range coverage. The detection range is approximately 18 000 m against aircraft and between 8000 and 9000 m against hovering helicopters. Automation of the radar functions described above is performed through real-time data processing.

The post can monitor up to eight firing units including the Aspic systems and, if required, other weapon types such as MANPADS missile systems or anti-aircraft guns through tactical terminals. The maximum distance between the post and the firing unit is 5000 m. Data transmission



Thomson-CSF Samantha VSHORAD mobile command and control post during trials with the French Army





*Thomson-CSF Aspic firing post mount on rear of Peugeot P4 (4x4) light light cross-country vehicle*

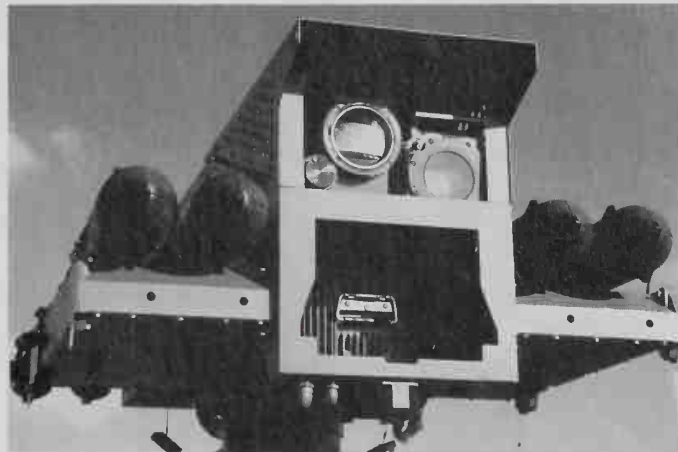
between them is via a radio frequency data link. The available firepower display can be adapted to meet the expected threat and to show the available anti-aircraft assets.

The Samantha system is the mobile shelter version for carriage on a truck chassis and is fitted with full NBC and EMI protection. The Mantha is a modular version carried on a 5 ton class light vehicle.

(b) up to four Aspic mobile firing posts. The Aspic two-axis servo-controlled turret can be mounted on a variety of chassis including 4 x 4 light vehicles such as the Peugeot P4. In this case it carries four ready-to-fire missiles and four reloads. The missiles can be of the Mistral, Stinger, RBS 70, Starburst or other suitable MANPADS type. The vehicle is also normally fitted with land and North seeking navigation system.

Normal crew of an Aspic system is two, the operator and vehicle driver. Although for the 'stand-alone' operating mode the driver should preferably be an operator-driver so he can act as the 'pointer'.

The firing station is fitted with a fire control system that has a TV tracking sensor package with TV camera, TV angle deviation measurement device, digital computer and vertical gyro. This allows for fast and automatic target acquisition, accurate target tracking and optimisation of the lead angle and validation of the designated missile IR seeker on the assigned target. An infra-red camera provides for a night time and reduced visibility engagement capability.



*Close up of the Thomson-CSF Aspic firing post showing the sensor package in the centre and the two fire-and-forget missiles either side*



*Close up of the combat control display mounted inside of the Thomson-CSF Aspic firing post, this can be deployed away from the vehicle if required*

In the normal co-ordinated operational mode data is fed to and from the Aspic via an automatic radio link with the command post. Once a target is confirmed as hostile by the post then the target designation information is provided to the selected firing post.

If operated in the 'stand-alone' mode then the Aspic system uses a operator-driver as a 'pointer' with a helmet-mounted optical target designator system known as ARES. This allows for fast deployment and almost instantaneous reaction from the main system operator at the deployment site.

Turret traverse is 360° and it can be controlled by the operator using a remote firing control console from up to 50 m away.

**Status:** Production. In service with several countries including Gabon and an undisclosed South American nation.

**Manufacturer:** Thomson-CSF, Division Systèmes Électroniques, 9 rue des Mathurins, BP150, F-92223 Bagneux Cedex, France.  
Telephone: (1) 40 84 40 00  
Telex: THOM 616780F

## Thomson-CSF Shahine 1/Shahine 2 Low Altitude Surface-to-air Missile Systems

### Development

In 1975 Thomson-CSF was awarded a contract from Saudi Arabia for the design, development and production of a mobile all-weather low altitude, self-propelled surface-to-air missile system called Shahine 1. The contract covered the supply of several Shahine 1 batteries, each comprising two acquisition units and four firing units mounted on AMX-30 MBT chassis. The batteries were delivered to Saudi Arabia from January 1980 through to 1982.

Saudi Arabia also ordered the AMX-30SA twin 30 mm self-propelled anti-aircraft gun system to operate with the Shahine batteries (details of the AMX-30SA are given in the *Self-Propelled Anti-aircraft Gun* section).

In January 1984, Saudi Arabia announced the placing of the 'Al-Thakeb' contract with Thomson-CSF. This mainly involved the supply of an improved Shahine version, known as Shahine 2, mounted either on the AMX-30 chassis or on a towed shelter. The latter being known as the Air Transportable Towed System (ATTS). The modular design of the acquisition and fire unit systems allows them to be installed on either platform system. A further contract was awarded to Thomson-CSF in 1990 to upgrade several Shahine 1 batteries to the Shahine 2 standard.

Thomson-CSF Electronics Systems Division acts as the prime contractor for the radars and electronics of the weapon systems. Engins Matra is responsible for the missile.

### Description

The basic Shahine version is mounted on the chassis of the AMX-30 MBT which has improved cross-country mobility compared to wheeled vehicles in the desert climate. An added advantage is that Saudi Arabia also operates the AMX-30 MBT.

The 32 700 kg acquisition unit has a pulse Doppler E/F-band surveillance radar (18.5 km range and 6000 m altitude target detection capability) and a digital receiver for the MTI function. The automatic data processing, including

threat evaluation, is carried out by computer that can record up to 40 targets and automatically initiate tracks on the 12 most threatening. A TV system featuring a TV turret, which is both concentric with and independent of the radar turret, provides ground monitoring of moving fire units and optical target reconnaissance.

The 38 800 kg firing unit comprises a monopulse Doppler J-band 17 km range fire control radar which simultaneously tracks the target and localises one or two missiles. The radar has a digital receiver and a circularly polarised antenna. The fire unit also includes a remote controller system which sends the missile guidance commands.

During the first part of the flight the missile is gathered in the radar beam by an infra-red sensor. In case of jamming, a TV system is integrated into the firing turret to ensure a backup mode for the target and missile tracking functions. The firing unit has six ready-to-fire missiles. When expended reload missile container-launchers are brought up and loaded by a Missile Transport and Loading Vehicle (MTLV).

The R460 missile of the Shahine system is an improvement of the R440 Crotale weapon. It is 3.12 m long, with a diameter of 0.156 m and a wing span of 0.59 m. Total weight is 100 kg of which 15 kg are the focus splinter warhead. This is triggered by a contact, infra-red (IR) or electromagnetic (EM) proximity fuze. The lethal radius is about 8 m.

Behind the missile nose cone, which contains the proximity fuzing circuitry, is the section that houses the converter and pitch and yaw actuators. The latter actuate control fins mounted on canard surfaces. The next section along accommodates the battery, electronic control box and interconnections, various support instruments, the warhead and the safety and arming device. The next section contains the rocket motor that boosts the missile to its maximum speed of Mach 2.8. The solid propellant used is manufactured by SNPE and is of the double base extruded type. The combustion period lasts about 4.5 seconds.

The final section of the missile comprises the remote-control receiver and transponder, the roll actuator, the infra-red tracer and the nozzle. Large cruciform surfaces around this section are equipped with antennas or roll fins driven by the roll actuator.



Shahine ATTS acquisition unit with APU on right and operator's cabin on left



Shahine-ATTS firing unit with six missiles in ready to launch position and four stabilisers lowered to ground



Shahine firing unit on GIAT Industries AMX-30 MBT chassis



Shahine acquisition unit on GIAT Industries AMX-30 MBT chassis





*Firing unit of Shahine with missile leaving upper container*

For a typical target such as a fighter with 250 m/s (Mach 0.75) velocity and 1 m<sup>2</sup> fluctuating radar cross section the following engagement parameters apply:

**HEAD-ON TARGET**

maximum operational intercept range	11 800 m
minimum operational intercept range	500 m

**CROSSING TARGET**

maximum operational intercept range	8000 m
minimum operational intercept range	2000 m

**TARGET ALTITUDE**

maximum	6800 m
minimum	15 m

The Single Shot Kill Probability (SSKP) for a single missile is 0.9 and for a salvo of two 0.99.

The R460 missile has the following performance:

Range	Manoeuvrability*	Flight Time
6000 m	35 g	11 s
10 000 m	15 g	23 s
14 000 m**	8 g**	45 s**

**Notes:**

\* The manoeuvrability (or load factor) of the missile is the maximum number of g which can be applied to the weapon in pitch and/or yaw when under guidance

\*\* Approximate values.

The Inter-Vehicle Positioning and Data Link (IVPDL) allows complete Shahine system deployment to occur over a large area via J-band microwave data links and reciprocal location information to be exchanged between acquisition and firing units. The IVPDL capability covers 500 to 4000 m



*Renault TRM 10 000 (6 x 6) cross-country truck used as Shahine Transport and Loading Vehicle. Hydraulic crane at rear can lift new pack of three missiles*

between firing and acquisition units and 7000 m between acquisition units. Other data links can be connected to the acquisition unit so that it can communicate with a higher command echelon, enabling the system to be integrated into an overall air defence network.

The main differences between the Shahine 1 and Shahine 2 versions are the increase in the acquisition units radar range to 19.5 km, the incorporation of the Shahine Data Link (SHADL) to allow the Shahine 2 batteries to exchange data to and from a command and control centre and the use of the electromagnetic fuze to replace the current IR one.

**Status:** Production complete - a total of 36 acquisition and 73 firing units were built on AMX-30 chassis, and 10 acquisition and 19 firing units in the ATTS shelter configuration. In service with the Royal Saudi Land and Air Defence Forces.

**Manufacturers:** Thomson-CSF, Division Systèmes Électroniques, 9 rue des Mathurins, BP150, F-92223 Bagneux Cedex, France.

Telephone: (1) 40 84 40 00

Telex: THOM 616 780F

**Missile:**

MATRA, 37 avenue Louis Breguet, BP, F-78146 Vélizy-Villacoublay, France.

Telephone: (1) 39 46 96 00

Telex: 968007 F

## Thomson-CSF Crotale Low Altitude Surface-to-air Missile System

### Development

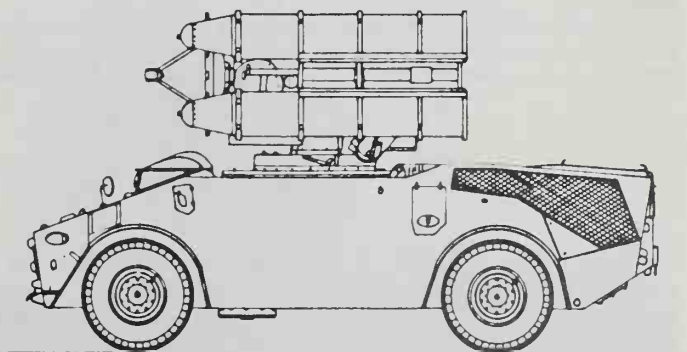
Following the British Government's refusal to supply South Africa with surface-to-air missiles, in 1964 South Africa placed a development contract with the French company, Thomson-Houston (later Thomson-CSF) for a mobile, all-weather, low altitude surface-to-air missile system. The Electronic Systems Division of Thomson-CSF was prime contractor for the complete system including the radar and electronics and Engins Matra was responsible for the missile.

The South African Government paid 85 per cent of the development costs of the system, which it calls the Cactus, and the remaining 15 per cent was paid by France. After trials in 1971 the first of seven platoons was delivered to South Africa with the final one delivered in 1973.

In February 1971 the French Air Force placed an order for one acquisition vehicle and two firing units which were delivered in 1972. After extensive trials with these units the French Air Force ordered the Crotale (Rattlesnake) system for airfield defence and by late 1978, 20 batteries had been delivered.

Lebanon ordered the Crotale in the late 1960s but the order was cancelled before the systems were delivered. In 1975 Saudi Arabia ordered a new version of the Crotale mounted on the chassis of the AMX-30 MBT, known as the Shahine, for which there is a separate entry as the system has a number of improvements over the standard Crotale. The Saudis also ordered the standard Crotale in late 1978 for their Air Force.

As produced at present Crotale is mounted on a P4R (4 x 4) vehicle and can also be mounted on a tracked chassis for increased cross-country mobility, or shelter-mounted for use in static defence (the latter is known as the Crotale-S system). The first Crotale, produced in 1969, was called the



*Crotale P4R firing unit with four ready to launch missiles*

1000 series. This was followed by the 2000 series in 1973, 3000 series in 1975, 4000 series in 1983 and the 5000 series in 1985. Crotale 3000 fire and acquisition units are not ready for action as soon as they come to the halt but have to be connected together by cables at a maximum distance of 800 m apart. The 4000 series have the LIVH (Liaison InterVéhicule Hertzienne) radio link and mast which not only allows them to connect into action faster but also to be up to 10 000 m apart to cover more area. The 5000 series have further improvements such as the possibility of mounting two MATRA Mistral missiles either side of two of the Crotale container-launcher canisters to help meet saturation air attacks.



*Crotale Series 4000 P4R firing unit with three hydraulic jacks lowered to provide more stable launching platform, showing radio link system mast extended*

In November 1988, at the 2nd ASIINDEX exhibition in Beijing, the China Precision Machinery Import and Export Corporation (CPMIEC) revealed the FM-80 land-mobile shelter-mounted surface-to-air missile system on two-axle trailers. The FM-80 is very similar in concept to the Crotales-S and its naval equivalent. Details of FM-80 are given in the *Static and Towed SAM Systems* section.

#### Description

The basic Crotales has an all-weather capability. A typical platoon consists of one acquisition unit and two to three firing units with a battery having two platoons. All the operators, except Libya, Saudi Arabia and Abu Dhabi

(UAE), have one radar acquisition vehicle to two firing units. The three exceptions have one radar vehicle to three firing units. The system cannot operate on the move and takes less than five minutes to become operational once it has stopped. Once the target has been detected the missile can be launched within about 6.5 seconds. The system has been designed to combat targets flying at a speed of Mach 1.2 at an altitude of 50 to 3000 m and an equivalent radar area of 1 m<sup>2</sup> fluctuating. Data is transmitted from the acquisition unit to the firing units via a cable that allows operations up to 400 m (Crotales 3000 and later versions 800 m) away or via a radio link from 50-5000 m away. Between the fire/acquisition units of the Crotales 4000 and later versions the maximum radio link range is increased to 10 000 m.

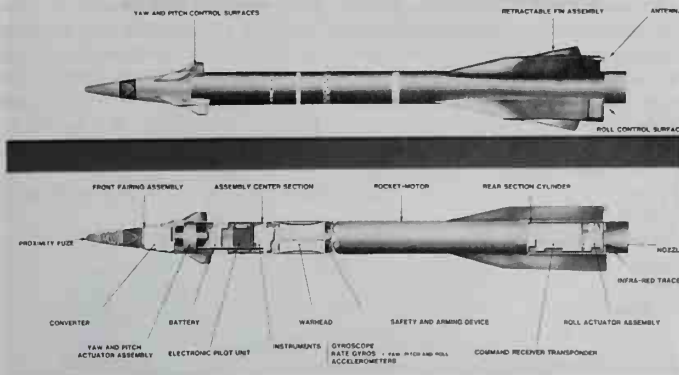
Both vehicles have an all-welded steel hull with the driver at the front, electronics and operators in the centre and the thermal motor at the rear. There is a door in the right side of the hull which opens to the rear. Energy is provided by the thermal motor. An alternator, driven by the thermal motor, produces power, the output of which is rectified and then fed to a series of DC motors which in turn drive each of the four road wheels by epicyclic reduction gears. Sufficient electric power is provided for all the vehicle's electrical systems including the electronics, air-conditioning system and the hydraulic circuit which operates the three levelling jacks, steering, suspension and brakes. Each road wheel station has a hydraulic and pneumatic suspension system designed by Messier. This acts as a pneumatic spring, suspension spring and shock absorber simultaneously. The position of each jack is controlled by a selector valve connected to a differential gear and the driver has a lever which enables him to select one of five positions.

The acquisition unit carries out target surveillance, identification and designation. Mounted on the top of the vehicle is a Thomson-CSF E-band Mirador IV pulse Doppler radar which rotates at 60 rpm and has a maximum detection range of 18.5 km against low level targets with speeds of between 35-440 m/s and altitude limits between zero and 800 m, and 15 km against high level targets with the same speed range and altitude limits between 1800 and 4500 m. The system also has an IFF interrogator-decoder, a non-saturable extractor, real-time digital computer, display console and a digital data link for transmitting information to the firing units. The computer, which is the same as that installed in the firing unit, is used to generate accurate data for confirmation of threat evaluation. Thirty targets can be processed



*Shelter-mounted Crotales-S acquisition unit mounted on rear of Renault TRM 9000 (6 x 6) truck and showing antenna folded for travelling*



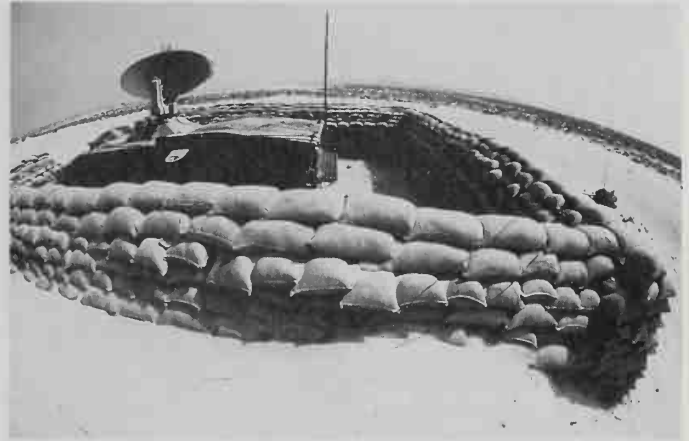


Main components of Crotale R440 missile

per antenna revolution with up to 12 targets simultaneously tracked by the system.

Once the target has been detected the computer triggers the IFF interrogator and the final threat information is displayed. The target is then allocated to one of the firing units and target designation data and operational orders are transmitted by the data link which also supplies information from the firing unit on operational status, for example, the number of missiles available.

The firing unit has a J-band monopulse 17 km range single target tracking radar mounted concentrically with the launcher turret, which carries four ready to launch missiles, two each side. The system also has an I-band 10° antenna beamwidth command transmitter, infra-red gathering system with a 5° wide field-of-view (and in French Air Force systems a further narrow field-of-view mode for passive operations), an integrated TV tracking mode as a low elevation backup, an optical designation tripod-mounted binocular device (which is controlled manually by a handlebar arrangement and used primarily in a heavy ECM environment or whenever passive operation is required), digital computer, operating console and a digital data link. All the vehicles are fitted with an inter-vehicle link network to transmit data and orders by cable and for radio communication by a VHF radio-link.



Thomson-CSF Crotale acquisition system deployed in the Gulf early in 1991

The radar can track one target and guide two missiles simultaneously. The missiles, fired 2.5 seconds apart, are acquired immediately after launch by the 1.1° tracking beam of the radar with the help of infra-red detection and radar transponders during the gathering phase. There is also an optronic system. Guidance signals are transmitted to the missiles by radio.

No spare missiles are carried on the vehicle and fresh missiles are brought up by a truck and loaded with a light crane. A well-trained crew of three can load four missiles in about two minutes.

The missile is designated the R440 and weighs 84 kg, has an overall length of 2.89 m, span of 0.54 m and a diameter of 0.15 m. The missile complete with its transport/launch container weighs 100 kg. The HE focused fragmentation warhead in the centre of the missile weighs 15 kg, has a lethal radius of 8 m and is activated by either the infra-red proximity fuze (the fuze is commanded to activate 350 m before interception) or backup contact fuze. The missile has a SNPE Lens III rocket motor with 25.45 kg of solid propellant powder. The missile reaches a maximum speed of 930 m/s in 2.8 seconds.

For 1 m<sup>2</sup> radar fluctuating cross-section targets with velocities of 50 and 200 m/s respectively the following engagement parameters apply:



Crotale P4R firing unit launching missile with launcher traversed to rear



Crotale-S firing unit in static configuration



*Crotale P4R series 4000 acquisition unit with radio link system mast raised and radar rotating*

	Velocity	
	50 m/s	200 m/s
<b>HEAD-ON TARGET</b>		
maximum operational firing range	11 200 m	10 500 m
minimum operational firing range	500 m	500 m
<b>CROSSING TARGET</b>		
maximum operational firing range	9700 m	5500 m
minimum operational firing range	500 m	2000 m
<b>TARGET ALTITUDE</b>		
maximum	5500 m	5000 m
minimum	15 m	15 m

The Single Shot Kill Probability (SSKP) for a single missile is 0.8 and for a salvo of two 0.96.

The missile is itself capable of the following performance:

Range	Manoeuvrability*	Flight Time
5000 m	27 g	10 s
6000 m	18 g	13 s
10 000 m	8 g	28 s
13 000 m	3 g	46 s

**Note:** \* the manoeuvrability (or load factor) of the missile in terms of time is the maximum number of g which can be applied to the weapon in pitch and/or yaw when under guidance.

The maximum range that Crotale has been guided to against a slow moving target (for example, helicopter) is 14 600 m.

Minimum flight time is 2.2 seconds (the time required to arm warhead section).

In early 1987 Thomson-Brandt Armement (TBA) tested a new HE-fragmentation warhead for Crotale. This uses a time-space convergence technique to ensure that the warhead fragments arrive coincidentally within a 40 cm band at a distance of 5 to 8 m irrespective of the missile/target miss distance. The fragments are capable of penetrating up to 10 mm of steel plate within this range or severing the aluminium alloy body of a missile.

#### SPECIFICATIONS

Type	Acquisition vehicle	Launch vehicle
CREW	2	2
COMBAT WEIGHT	12 620 kg	14 950 kg
LENGTH	6.22 m	6.22 m
WIDTH	2.72 m	2.72 m
HEIGHT		
(reduced for air transport)	3.05 m (max)	3.41 m (max)
<b>GROUND CLEARANCE</b>		
travelling	0.45 m	0.45 m
action	0.156-0.656 m	0.156-0.656 m
WHEELBASE	3.6 m	3.6 m
MAX ROAD SPEED	70 km/h	70 km/h
MAX RANGE	600 km	600 km
FORDING	0.68 m	0.68 m
GRADIENT	40% at 2 km/h	40% at 2 km/h
	10% at 25 km/h	10% at 25 km/h
<b>VERTICAL OBSTACLE</b>	0.3 m	0.3 m
<b>ARMOUR</b>	3-5 mm	3-5 mm

**Status:** Production as required. In service with the following countries:

Country	Quantity acquisition units	Quantity fire units	User
Chile	2	4	air force
Egypt	12	24	air defence command
France	24	48	air force
Libya	9	27	air defence command
Pakistan	12	24	air force
Saudi Arabia	16	48	air defence command
South Africa	7	14	air force
UAE	3	9	army

Marketing is now being concentrated on the Crotale New Generation covered in the following entry and key components of this system can be backfitted to the earlier Crotale system.

**Manufacturers:** Thomson-CSF, Division Systèmes Électroniques, 1 rue des Mathurins, BP 10, F-92223 Bagneux Cedex, France.

Telephone: (1) 46 57 13 65

Telex: 204780 F

**MATRA**, 37 avenue Louis Breguet, BP 1, F-78146, Vélizy-Villacoublay, France.

Telephone: (1) 39 46 96 00

Telex: 968007 F

## Thomson-CSF Crotale NG Low Altitude Surface-to-air Missile System

### Development

The Crotale NG (Nouvelle Génération: New Generation) low altitude SAM system was originally launched in 1985 under the name Liberty for inclusion in the US Army's FAADS-LOS-FH competition.

Crotale NG differs from the original Crotale system in having all the acquisition, tracking, firing and computer units mounted in a single vehicle.

The modular all-weather system is divided into six main subsystems which can be carried on a variety of platforms ranging from a simple shelter to armoured vehicles such as the M2/M3 Bradley IFV family, the Korean Infantry Fighting Vehicle (KIFV), the Krauss-Maffei Puma, the latest re-engineered versions of the FMC M113 APC or the Finnish wheeled SISU XA-180 (6 × 6) APC.

The VT-1 missile, developed for Thomson-CSF and Crotale NG system, since 1986 by the Missiles Division of the American company LTV Missiles and Electronics Group, successfully completed a series of test firings in March 1989.

The first prototype shelter system was used in 1988 for tracking trials whilst the first complete system trials, using the shelter unit, took place in 1990 with the VT-1 missile. System integration was undertaken in France with the initial batch of 1000 VT-1 missiles and 42 re-usable launch pod containers being built in the USA. Production of these began in mid-1989 with the series being shipped in 1991 under a contract signed by LTV with

Thomson-CSF in 1986. Completion of the production run is due by December 1992.

The initial American missile production is being followed by a progressive production shift to Europe. In September 1991 Thomson-CSF signed an agreement with the Euromissile consortium (Aerospatiale and MBB) to start producing the VT-1 missile from around 1993-94 onwards. Apart from its use with Crotale NG the weapon is also being integrated into the Euromissile Roland 3 programme (qv entry this section). Workshares are split equally between the French and German partners with MBB concentrating on the warhead and Aerospatiale undertaking final assembly. Euromissile is subcontracting portions of the programme to US suppliers, including Rockwell for electronics, Moog for actuators and Thiokol for the propellants.

Elements of the Crotale NG system such as the VT-1 missile, electro-optical module and acquisition unit can also be introduced into the Crotale 4000 system, either as new build items or retrofitted into existing Crotale systems.

In 1988 the Crotale NG was selected by the Finnish Army as its low level air defence weapon to fill the gap between the manportable SA-7 'Grail'/14 'Gremlin'/16 'Gimlet' weapons and the static SA-3 'Goa' systems it operates. Initial deployment of the 20 fire units with Thomson-CSF TSM 2630 radars ordered and mounted on locally designed and built SISU XA-180 (6 × 6) APCs occurred in 1991. The delivery period is spread over 2-3 years. The APC hull is sent to France complete with its APU and NBC systems for fitting out.

Following this Finnish order the Royal Netherlands Air Force selected the Crotale NG system to protect seven of its air bases. A total of 14 fire units in





*Shelter-mounted version of Crotales New Generation with outriggers deployed in position*

the shelter configuration (with seven more on option) are required. When the Dutch Parliament ratifies the contract these units will be delivered three years after the order has been placed. They will be adapted for use with the Hollandse Signaalapparaten BV (HSA) Flycatcher central fire control systems.

By mid-1991 the French Air Force had selected the shelter form of Crotales NG to protect its air bases. This version is fitted on a completely self-contained air transportable shelter suitable for rapid overseas deployment operations. The French Air Force system will also be modified for two-man operations. An initial batch of 12 units has been ordered for delivery to the French Air Force in 1993-94.

Thailand has also selected the Crotales NG, in its shelter version for the Royal Thai Air Force and in a tracked version for the Royal Thai Army. In mid-1991 the Thai Supreme Command requested Cabinet budget approval to acquire 20 Crotales NG systems at a total cost of Baht 25.54 billion (\$944 million). In the same region Singapore is reported to have purchased the Crotales NG.

The Crotales NG has also been shortlisted by Turkey (under a proposed contract with the Turkish company STFA Savronik as the Yılan (Turkish for snake) for an eventual 30 to 70 per cent co-production deal following assembly of the first eight fire units in France. This agreement is in order to meet the minimum requirement of 196 vehicle-mounted firing units (and 2352 missile rounds) by the Turkish Land Forces Command.

South Korea has shortlisted the Crotales NG system as well to meet a requirement for a low air defence system. If selected this programme will also be a joint production venture (it is believed to have the local name Chun-Me).

### Description

The Crotales NG electrically driven turret weighs around 4000 kg and includes a surveillance radar with associated IFF subsystem, a cupola housing a tracking radar, electrical optical equipment including a day and night Forward Looking Infra-Red (FLIR) camera, a daylight only TV camera, video tracking and an infra-red (IR) localiser and eight ready-to-fire missiles in two packs of four container-launcher tubes.

The standard option surveillance radar is the Thomson-CSF TSM 2630 E-band frequency-agile pulse compression Doppler model with a 40 rpm planar antenna, improved ECCM features (including strobe-on-jam, low side lobes, wideband frequency agility and constant false alarm rate) and search-on-the-move capability. Detection range against high performance aircraft is approximately 18-20 000 m and around 8000 m on a hovering helicopter. Altitude coverage is from ground level to around 5000 m. An



*Operators console of Crotales New Generation being used in tracking mode on a helicopter*

automatic track-while-scan capability provides track details on up to eight targets whilst simultaneously evaluating the threat.

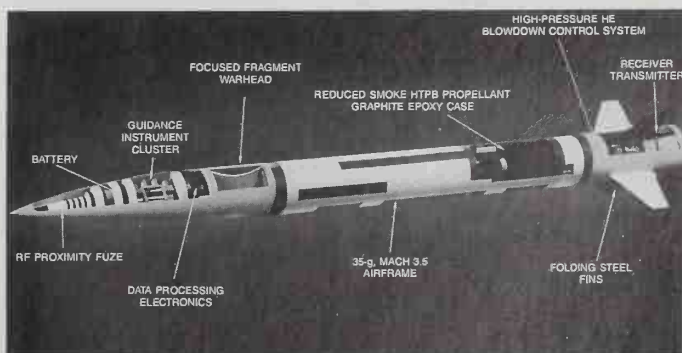
The tracking radar fitted is of the frequency-agile monopulse Doppler type with improved ECCM features (including low side lobes, wideband frequency agility, multi mode (burst-to-burst or pulse-to-pulse frequency agility), constant false alarm rate and jammer tracking), operating in the J-band with a range of up to 30 000 m on target types from hovering helicopters to Mach 2 plus aircraft.

The passive operation electro-optical systems comprises: a Castor double field-of-view ( $8.1 \times 5.4$  wide and  $2.7 \times 1.8$  narrow) thermal imaging TV camera (with a maximum acquisition range of up to 19 000 m which reduces to around 10 000 m in optical visibility conditions); a Mascot day-view single  $2.4 \times 1.8$  field-of-view CCD TV camera (with a range of up to 15 000 m); a video tracker for automatic tracking of the target and missile and a large field-of-view IR localiser to track the missile in its initial few seconds of flight.

The VT-1 missile itself weighs 75 kg at launch (with its container-launcher tube the total weight is raised to 95 kg) and is 2.29 m long and 0.165 m in diameter. Four-folding steel fins open out after launch to stabilise it. A Thomson-Brandt 14 kg focussed fragmentation HE warhead is carried which uses a pseudo-randomly pulse-modulated broadband electromagnetic proximity fuze. This is activated by the missile's onboard firing circuit processor using a time delay set to operate at a time between 0.2 and 0.5 seconds before the projected target interception point is reached. Lethal radius of the warhead is 8 m.

The missile has a maximum range of 11 000 m, a minimum range of around 500 m and an altitude engagement limit of very low to 6000 m.

Maximum missile speed is Mach 3.6, which is achieved by using an improved version of the Sidewinder air-to-air missile solid propellant rocket



*VT-1 missile showing position of main components*

motor developed by Morton Thiokol specifically for the VT-1 project. The weapon has a flight time of 10 seconds to 8000 m range and is capable of manoeuvring under load factors of up to 35 g at this distance.

Missile guidance is by an IR deviation measurement system or narrow radar beam using the multi-sensor guidance principle which Thomson-CSF has incorporated into its naval Crotale system.

This principle involves using all the sensors to send their data to the onboard computer which then processes it, after filtering out such interferences as clutter, decoys or jamming in a few milliseconds, to determine the guidance control commands to be uplinked to the missile.

In a normal engagement mode, both the radar and the electro-optical systems operate together and constantly check each other. The tracking systems define the observation window that displays the target, the missile to be tracked and the false targets already detected.



VT-1 missile being launched during trials at the French Air Force Test Centre

Within this defined window are the measured windows associated with each target to be tracked, the physical measurements made by the different sensors are correlated in each measuring window. All the collected data packages are sent to a 2D digital filter and the best estimate of target and missile positions is extracted. Any control orders to the missiles are passed through the narrow beam, frequency-agile remote-control guidance radio uplink channel of the radar system.

A colour console displays the alphanumeric data on the targets, the TV and thermal images and the video images from the tracking radar, the surveillance radar scope and information on the available missile. All the operator has to do is follow a computer-generated menu displayed on the console and select the desired functions by pressing buttons.

The target engagement cycle from detection to interception is entirely automatic with the gunner only pressing buttons twice to ensure the safety of friendly aircraft. Reaction time is very short at five seconds or less with the total engagement time for target detection and final interception at 8000 m range being estimated at approximately 15 seconds. Re-engagement time is one or two seconds depending upon whether the target is isolated or in a group. It is theoretically possible for a single firing unit to engage two separate groups of four aircraft each and destroy all of them at a distance of between 500 to 11 000 m. Reloading the two missile packs takes around 10 minutes.

**Status:** Production. Selected by, ordered for or in service with the following countries: France (Air Force — initial batch of 12 air-portable shelter units ordered), Finland (Army — 20 units on SISU XA-180 (6 × 6) APC being delivered), the Netherlands (chosen by Air Force — firm order for 14 shelter units plus seven shelter unit option still to be placed by late 1991), Singapore (unconfirmed order) and Thailand (batch of 20 units requested for Air Force (shelter version) and Army (tracked vehicle version)).

**Manufacturer:** TSM 2630 radar and prime contractor system integration, Thomson-CSF, Division Systèmes Electroniques, 9 rue des Mathurins, BP150, F-92223 Bagneux Cedex, France.  
Telephone: (1) 40 84 40 00  
Telex: THOM 616 780F



Crotale New Generation for Finland mounted on SISU XA-180 (6 × 6) APC

## MATRA SANTAL Low Altitude Surface-to-air Self-propelled Missile System

### Development/Description

The MATRA SATCP Mistral (Système Antiaérien à Très Courte Portée) portable surface-to-air missile system can also be integrated in a turret-mounted version on a variety of different light armoured vehicle chassis. After studies of the VAB and Panhard ERC (6 × 6) vehicles, the latter was accepted for service with the French Army but due to financial reasons procurement has now been dropped. As the trial stage was already funded this was continued and completed by the end of 1990 to gain data on the system.

The SANTAL (Système Antiaérien Autonome Léger) turret has been designed by Hispano-Suiza and is fitted with three missiles either side of the turret in the ready to launch position with a further six missiles carried within the vehicle's hull. Mounted on the turret rear is a surveillance unit such as the Dassault Electronique RODEO 2 E/F-band pulse Doppler radar.

The first prototype turret (PO1) was completed by Hispano-Suiza in May 1987 and mounted on the Panhard ERC chassis with the second prototype turret (PO2) following later the same year and subsequently being mounted on a VAB (6 × 6) chassis.

MATRA is the prime contractor for the complete system including the turret, and following delivery from Hispano-Suiza, they integrate the Thomson-TRT Défense Castor thermal camera, RODEO 2 radar system, fire control system and two three-round launchers. A further six reserve missiles are carried, three either side of the hull above the two rear road wheels and ready for manual reloading on the ERC, and within the vehicle on the VAB.

The turret weighs 1800 kg complete with six missiles and its two-man crew consists of a radio operator/vehicle commander and a missile operator. For local protection a 7.62 mm machine gun can be installed on the roof of the turret, and mounted on the forward part of the turret are four electrically operated smoke dischargers.

The system has a crew of three; the driver, missile operator and radar operator/commander. The last two sit in the turret with the radar console and fire control equipment.





*SMS VAB (6 × 6) vehicle fitted with SANTAL turret with six Mistral SAM in ready to launch position*

The turret has full electric power traverse of 360° at 50°/s and the missiles in their launch boxes can be elevated from -10 to +60° at a speed of 50°/s; manual controls are provided for emergency use. The gunner has periscopes for all-round observation, plus a Sapelem M411 daytime optical target acquisition periscopic sight in the forward part of the turret roof with magnifications of ×1 and ×6, and a Thomson-TRT Défense Castor two field-of-view thermal camera mounted on the left-hand side of the turret. The turret has a single-piece hatch cover that opens to the rear, two electrically operated smoke dischargers either side and can be fitted with a spotlight.

A typical target engagement takes place as follows. The search radar first detects the target and if it is confirmed as hostile the turret is traversed onto the target bearing. The gunner then searches for the target in elevation using the thermal camera or periscopic sight, once he finds the target he keeps tracking it. When the target is within range a missile is launched and no further action is required by the gunner.

The Rodeo 2 radar can detect a partially masked hovering helicopter at over 6 km and a stationary unmasked helicopter at over 8 km. The range for aircraft and moving helicopters exceeds 12 km. Two targets can be tracked simultaneously and the radar is fitted with a built-in device enabling identification of the detected helicopter and discrimination between fixed- and rotary-wing aircraft. The radar is also IFF compatible.



*Panhard ERC (6 × 6) chassis fitted with SANTAL turret*

The missile itself has a launch weight of 17 kg and is 1.8 m long and 90 mm in diameter. The 3 kg high explosive warhead contains a large number of tungsten balls and has a laser proximity fuze with a precise distance cut-off feature to reduce the chances of premature triggering by ground or sea clutter, it also has an impact fuze. The pyramid-shaped infrared homing head can engage aircraft or helicopters from any angle. Maximum speed of the missile is Mach 2.5 and the minimum and maximum ranges are 500 and 6000 m respectively, with an engagement altitude against Mach 1.2 targets of up to 3050 m. Against a lightweight manoeuvring helicopter the maximum range is reduced to around 4000 m.

**Status:** Trials of the SANTAL turret installed on Panhard ERC (6 × 6) and SMS VAB (6 × 6) chassis were completed by the French Army in 1990 but there is no production funding for the SANTAL turret at present. MATRA is however continuing to market the SANTAL to a number of potential customers on various chassis including the FMC M113.

**Manufacturer:** Prime contractor for the missile and systems based on the SATCP Mistral missile is MATRA, 37 avenue Louis Breguet, BP 1, F-78146 Vélizy-Villacoublay, France.  
Telephone: (1) 39 46 96 00  
Telex: 968007 F

## GERMANY

### High Energy Laser Air Defence Armoured Vehicle

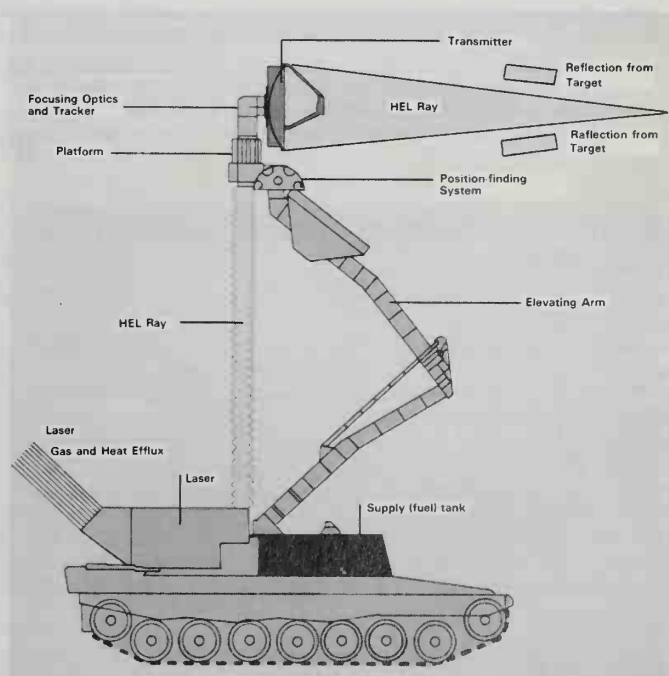
#### Development/Description

The German companies of Diehl and MBB Aerospace have joined together to develop a short-range High Energy Laser (HEL) system for use at the divisional level against low flying, high performance battlefield aircraft, missiles and helicopters.

The project incorporates a 10.6 µm wavelength HEL generator, sights and passive tracking and target acquisition sensors on a tracked vehicle. As the laser used is a dynamic carbon dioxide gas type the vehicle will carry commercial hydrocarbon fuel and the nitrogenous oxidator needed to generate the energy required for the tactical laser air defence role. The vehicle will thus be able to be refuelled with these materials as well as with its own diesel fuel. Combustion of the two components forms the carbon dioxide which is then passed through a line of Laval nozzles causing it to expand until it reaches supersonic speeds and is directed through an optical resonator to stimulate emission. The laser beam produced is directed upwards to a 1 m diameter focusing mirror on an extendable arm, to be fired at a target. The hot fumes resulting from the gas formation are vented rearwards from the laser generator system.

The destructive effect of the HEL is achieved by focusing the beam onto a small spot to give very high energy density in a very short space of time which causes a material to become successively heated, melted and vapourised. Combat range is expected to be around 8000 m.

**Status:** Study phase. Small scale version has been successfully tested in trials, German MoD funding provided.



*Main components of conceptual High Energy Laser system installed on tracked vehicle chassis*

## Dornier European Vehicle-Mounted Low Level Air Defence System (LLADS)

### Development

The Dornier European private venture LLADS has been designed as a cost-effective low weight modular air defence system to fill the gap between manportable missile weapons and complex heavy wheeled or tracked air defence missile systems.

Computerised operation of the missile launcher, sensors and an interface to a battlefield command, control, communications and intelligence system allows night and all-weather quick reaction capability and function in a multi-target environment. Typical system employment would be for point defence or escort (using its shoot whilst moving capability).

The system is air transportable with two units in a CH-53G Sea Stallion helicopter, three units in a C-130 Hercules transport or four units in a C-160 Transall transport.

### Description

The vehicle mounting the system is the Mercedes-Benz (4 × 4) 750 kg light all-terrain vehicle. The vehicle is fitted with a specially made stabilised pedestal on its rear decking which has direction controls for azimuth and elevation.

The pedestal can be fitted with a variety of sensors including either a Forward Looking Infra-Red (FLIR) system for target acquisition (at night or in adverse weather) or a Low Light Level TV (LLLTV) device (for limited night or adverse weather capabilities); a laser rangefinder mounted beside the primary target acquisition system to determine the distance to target-in-range decision; an electro-optical sight (a head-up display) and an Identification Friend or Foe (IFF) system.

The full LLADS sensor configuration characteristics available are:

	EO sight camera	LLLTV camera	FLIR camera	Laser rangefinder	IFF	Pre- assignment information
(1) Limited night fighting capability	No	Yes	No	Optional	Optional	Yes
(2) Limited night fighting capability	Yes	Yes	No	Optional	Optional	Yes
(3) Day/night fighting capability	Yes	No	Yes	Optional	Optional	Yes
(4) Day/night fighting capability	Yes	No	Yes	Yes	Yes	Yes

The gunner also has a mechanical sight fitted in all the pedestal configurations above and can either use his control panel whilst seated within the pedestal mount or remotely at a distance up to 50 m away.

On either side of the mount are two vertically fixed standard Air-To-Air Stinger (ATAS) launcher modules, weighing 46.1 kg each and with a total of four ready to launch Stinger missiles. Full details of the Stinger missile versions are to be found in the *Manportable Surface-to-Air Missile Systems* section of this book.

The individual launcher module incorporates the launcher structure, a mechanical interface, an electronics package and a cooling system. It is



*Dornier European Vehicle-Mounted Low Level Air Defence System (LLADS) on Mercedes-Benz (4 × 4) 750 kg all terrain vehicle*

operated by the fire control system of the carrier via interface electronics and can be used with all the Stinger missile versions.

The field-of-fire is  $-10^{\circ}$  to  $+60^{\circ}$  in elevation and  $360^{\circ}$  in traverse. Storage for four additional Stinger launcher-container tubes is available beneath the pedestal mount. The Stingers also retain their shoulder launch capability using the gripstock assembly.

The vehicle also carries an antenna and communications system for pre-assignment tasking via the C<sup>3</sup>I network, a Northing Gyro to obtain a north reference and a Global Positioning System (GPS) unit to provide accurate position co-ordinates for defence networking the LLADS.

### Variants

The standard Stinger ATAS module has also been adopted by Dornier for use with the 40 mm Bofors L70 air defence gun. A boxed set of two ATAS modules and target acquisition system is mounted on the top on the gun mount by the ammunition feed area.

Other examples of Stinger adaptations are the PAH 2 anti-tank helicopter, the BSH 1 escort helicopter, the 40 mm Navy Type 58 air defence gun and the Jpz Panther anti-armour tank.

**Status:** Advanced development.

**Manufacturer:** Dornier GmbH, PO Box 1420, D-7790 Friedrichshafen 1, Federal Republic of Germany.

Telephone: (7545) 80

Telex: 734209-0 do d

Fax: (7545) 8 44 11

## INDIA

## Akash Low to Medium Altitude Surface-to-air Missile System

### Development/Description

As part of the Integrated Guided Missile Development Programme (IGMDP) initiated by India in July 1983 enabling it to become self-sufficient in missile weapon production by the year 2002, the Department of Defence Research and Development Organisation is developing the Akash (Space) low to medium altitude medium-range mobile surface-to-air missile system.

The Akash is similar in general appearance to the Soviet SA-6 'Gainful' and uses a solid propellant rocket booster motor to accelerate itself to Mach 2 whereupon an advanced ramjet rocket sustainer cuts in for the remainder of the powered flight phase. The sustainer utilises a high energy composite solid propellant with a double base formulation which utilises finely powdered magnesium as the metallic fuel component rather than the

more usual aluminium fuel additive and, it is believed, nitrocellulose and nitroglycerine as the other components. The oxidisers are atmospheric oxygen and probably ammonium perchlorate.

The booster and sustainer rocket motor cases are flow-formed from maraging steel and titanium alloy respectively. Maximum engagement range is stated to be 27 000 m with the guidance system being of the semi-active homing type.

Three Akash rounds are carried on a multiple launch rail assembly mounted on the upper deck of a tracked vehicle chassis. Associated with the launcher is a separate Electronics Research and Development Establishment developed 3D phased-array radar, capable of handling multiple targets and fitted with all necessary ECCM features.

The system is due to be operational by 1995. The first flight trials took place in mid-1990.

**Status:** Development phase.



## Trishul Low Altitude Surface-to-air Missile System

### Development/Description

The Department of Defence Research and Development Organisation is developing the Trishul (Trident) low altitude, mobile, quick reaction, short-range surface-to-air missile system to meet a tri-service requirement as part of the Integrated Guided Missile Development Programme (IGMDP). This was initiated in July 1983 by India so it can become self-sufficient in missile weapon production by the year 2002.

The missile uses a flow-formed aluminium alloy structure, a fibreglass composite radome and a flow-formed maraging steel body and solid rocket motor case developed by DRDL. The dual thrust motor has an integral booster with the thrust controlled by the HTPB charge design.

Missile engagement range is 9000 m with an extremely short reaction time and high manoeuvring capability. A modified surveillance radar is used to track one target at a time with a modified Flycatcher air defence radar providing command guidance signals to the missile's onboard hybridised electronic control system.

The Army version comprises a twin rail launcher assembly and a Flycatcher radar unit mounted on a tracked BMP IFV chassis. The Indian Air Force will use a six-round launcher variant mounted on a locally built Czechoslovakian Tatra (8 × 8) truck chassis.

The first trial launch of a Trishul missile took place in February 1986 with eight launches in total having taken place by July 1989. Initial operational capability was due to be achieved with the Indian Army version in 1992–93.

**Status:** Low rate initial production phase. Entering service with Indian Army.

## INTERNATIONAL

## Euromissile Roland 1/Roland 2/Roland 3 Low Altitude Surface-to-air Missile Systems

### Development

In 1964 Aerospatiale of France and Messerschmitt-Bölkow-Blohm of Germany began design work on a low altitude surface-to-air missile system which eventually became known as the Roland. Aerospatiale had overall responsibility for the clear-weather version, called the Roland 1, and MBB overall responsibility for the Roland 2 all-weather version. At a later stage a joint company called Euromissile was established to market this and other missiles produced by the two companies. Currently the all-weather version (formerly called Roland 2) is offered together with the latest variant known as Roland 3.

The French Army had a requirement for 181 firing units based on the AMX-30 MBT chassis, designated for this purpose the AMX-30R. Of these, 181 have been funded to date, with all 98 Roland 2 and 83 Roland 1 vehicles now delivered. They are organised to provide the 51st, 53rd, 54th, 57th and 58th Roland regiments at Corps level, each of three batteries with two troops of four fire units apiece. Each Roland fire unit is accompanied in the field by a VAB (4 × 4) armoured personnel carrier mounting a 20 mm cannon in a GIAT Industries T20-2 turret for ground and anti-helicopter overwatch defence within the close-range dead zone of the Roland's engagement envelope. The first Roland fire units were delivered to the French Army in December 1977.

The first Roland firing trials unit was delivered to the German Army in 1978 as the replacement for the towed 40 mm L/70 Bofors guns. In June 1981 the German Army officially took delivery of the first of 140 Roland SAM systems. The first operational units were in fact delivered to the anti-aircraft school at Rendsburg in 1980. In July 1981 the 100th anti-aircraft rocket regiment of the German Army began re-equipment, followed by the 200th regiment in July 1982 and the 300th in July 1983. Each regiment has one HQ battery, three firing batteries (each with 12 fire units) and one support battery. In the German Army the system is based on the chassis of the Marder manufactured by Thyssen Henschel.

Brazil took delivery of four Roland 2 Marder fire units from Germany together with 50 missiles.

In 1984 the Spanish Defence Ministry selected the Roland for its mobile battlefield low level air defence system. The Pts 29 000 million contract placed was for integration and co-production of the weapon system (nine Roland clear-weather and nine Roland all-weather fire units on the AMX-30 MBT chassis with 414 missiles) in Spain.

Six Spanish companies were chosen to participate in the programme. INISEL is responsible for the electronic components (including the surveillance radars), fire units and production of the complete missile rounds. SANTA BARBARA is responsible for building the AMX-30 chassis, producing most of the missile components and total system integration whilst CESELSA has designed and built an indigenous IFF subsystem to meet national requirements.

To accommodate the system the Spanish Army has established the 350-man Roland Group within the auspices of the 71st Independent Air Defence Regiment. This comprises an HQ, an HQ battery, a services battery and two fire batteries each of two platoons with four fire units apiece.

Each platoon is expected to deploy two clear-weather and two all-weather systems. Of the remaining two vehicles one is to go for use in crew and maintainer training at the Artillery School while the other is to be used by the Artillery Missile Weapons Maintenance Centre.

In reality the Roland Group is an administrative device for centralising personnel training and equipment maintenance to reduce overall costs and optimise use of available resources.

The fire batteries will be attached operationally as *de facto* autonomous units to the 1st (Brunete) Armoured Division and the 2nd (Guzman el Bueno) Mechanised Division of the Immediate Intervention Forces. It is expected that they will operate in conjunction with units equipped with 40 mm L/70 Bofors towed guns.

The Roland Group was fully operational by the end of 1990. The next procurement goal for the Group is to obtain 16 BMR (6 × 6) wheeled fighting vehicles to use as fire unit escort vehicles. These will also transport section leaders and reserve crews as well as providing close-in fire protection to the AMX-30 fire unit.

A shelter version of Roland has also been developed and Argentina used a single example during the Falklands War of 1982 to defend Port Stanley against airstrikes from the Royal Navy Task Force. The system fired 8 out



German Army Roland 2 system on Marder chassis (Pierre Touzin)



Roland SAM being launched from a German Army Roland 2 system based on the Marder chassis



Marder chassis is used to mount the Siemens 30 km range radar system, shown here in elevated configuration. This version is called the Radarpanzer TÜR

of the 10 missiles it carried and is known only to have shot down one Sea Harrier and two 454 kg bombs. The system was captured intact. Iraq has used its Roland systems in combat against Iran.

A paired launcher ramp installation has been developed to meet saturation attacks by flights of 8 to 16 aircraft. Successfully tested in 1982 the launcher unit for the Roland 3 has two additional ramps fitted outboard of the existing ones, these tubes can also be loaded with Stinger fire-and-forget missiles if required. This raises the number of Roland missiles carried to 12 including four in the ready to fire position. The outboard ramps can be manually reloaded either in the field or during a resupply operation. The installation is designed for the truck and shelter versions, but it can be installed on an armoured vehicle chassis.

In December 1983 the Roland shelter variant was selected to protect the NATO US and German air bases in Germany. A further option for 95 firing units has been taken up, 27 to defend three US bases, 60 for twelve German bases (six for each six Tornado and four for each six Phantom bases) and the remaining eight units for training. All 95 units will be manned by German Air Force personnel. The agreement for the 27 Roland units for USAF bases was signed in June 1984. Besides this agreement, a further 20 Roland fire units were procured by the German Navy to protect three of its air bases. Delivery of the 115 units was:

	1986	1987	1988	1989	1990
USAF	—	8	16	3	—
German Air Force	3	2	14	33	16
German Navy	—	—	6	8	6

During mid-1984 more discussions were held between Germany and the USA to deploy an additional 30 Roland fire units manned by German personnel from the early 1990s onwards at US and German main operating and collocated operating bases. If taken up these would follow the 115 units already mentioned on the production line. The first production Euromissile Roland FlaRakRad was officially handed over to the German Air Force and Navy in September 1987, although three pre-production systems were delivered early in 1986 to enable training to commence.

The system is installed on the latest production MAN (8 × 8) high-mobility cross-country truck which has a number of minor improvements including a new three-man cab. The Luftwaffe Roland systems are supported by a MAN (8 × 8) 10 t truck fitted with a hydraulic crane and carrying replacement missiles. Adoption of the Roland 3 missile is underway.



Euromissile Roland FlaRakRad (8 × 8) in operational configuration with both tracking and surveillance antenna erected

In February 1988 AEG delivered the first Roland air defence fire control and co-ordination command post (known as Flugabwehr Gefechtsstand Roland: FGR) to the Luftwaffe. Installed as a three-man operated NBC-protected shelter unit on a MAN (8 × 8) 10 ton truck a total of 21 were delivered by the end of October 1990.

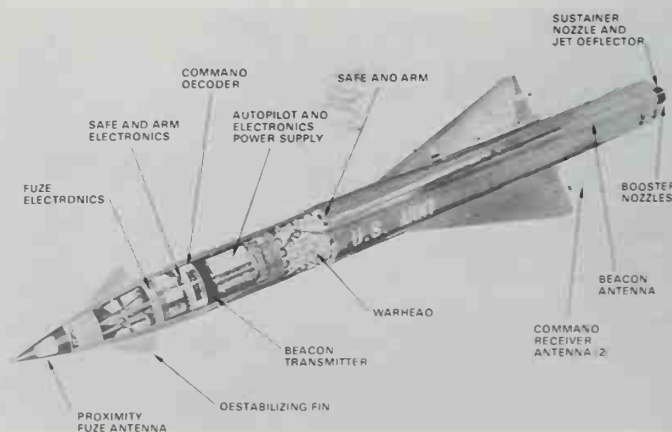
The 2D radar used is the TRM-L D-band frequency-agile model with integrated IFF system. This can distinguish between moving fixed-wing aircraft and helicopters as well as being capable of detecting anti-radiation missiles (ARMs) and hovering helicopters. Maximum elevation coverage is 60° within altitude limits of very low level to 6000 m. Detection range against a 1 m<sup>2</sup> target in high intensity ECM and clutter is said to be 46 km with a maximum radar range of 60 km claimed.

The antenna is mounted on a hydraulically raised 12 m high mast assembly. The whole system can be set up and made ready for operation within 15 minutes.

Two workstations are provided in the operator's section of the shelter, one for air situation processing and the other for operations control. The other two sections are the electronics bay and the protective systems bay with transmitter-cooling, air-conditioning and NBC units.

The FGR detects the targets (thus allowing the Roland fire units to shut down their surveillance radars so as to improve their own survivability against ARMs), processes the target information and displays it on an air situation display with an indication of the nature of the threat. The FGR commander decides on the most suitable air defence system, from up to 40 gun or missile systems he can control, to use for the engagement. The extensive onboard radio and cable-based communications suite is then used to inform the chosen weapon system of the target's parameters so that it can commence target acquisition and tracking. Data transfer to and from the weapons systems is carried out by radio or wire links whilst the voice links use either SEL SEM 80 and SEM 90 radios or field telephones. The system data renewal rate is two seconds.

For use with its Roland and Gepard anti-aircraft systems the German Army has the HFlaAFüSys low level air defence warning network. As part of this, Siemens AG produced the Radarpanzer TÜR (Tiefzieflieger-Überwachungs-Radar) vehicle based on a modified raised hull Marder ICV



Roland missile common to all firing unit systems





Roland 2 of the French Army deployed in firing position (Pierre Touzin)



Roland 2 of the French Army in travelling configuration with radars and missile retracted (Pierre Touzin)

chassis with the turret replaced by a hydraulically operated foldable 'cherry-picker' arm topped with a rotating radar antenna for looking over tree lines and extending the radar horizon.

The vehicle has a crew of four and contains the display and electronics for the E-band 30 km range MPDR 3002-S 2D radar, the electronic units of the integrated DII 211 (formerly MSR400/9) IFF subsystem, two operator workstations, an air situation processing system for the vehicle commander, a comprehensive communications suite and all the ancillary power supplies, cooling systems and hydraulic equipment required for their operational use. There is also a vehicle navigation system to ensure accurate vehicle positioning data.

Trials of the production standard (EPM C) radar on the TÜR vehicle were completed by the end of 1988 with the original TÜR prototype testing starting in late 1981.

The full contract list of French and German orders to date is as follows:-

	Roland I		Roland II	
	fire units	missiles	fire units	missiles
<b>Option 1A</b>				
France	34	1244	—	—
Germany	—	—	39	790
<b>Option 1B</b>				
France	46	1440	—	—
Germany	—	—	50	1684
<b>Option 2</b>				
France	—	680	36	1010
Germany	—	—	51	6520
<b>Option 3</b>				
France	—	—	40	2045
Germany	—	—	—	—
<b>Option 4</b>				
France	—	—	20	836
Germany	—	—	—	—
<b>Option 5</b>				
France	—	—	—	—
Germany	—	—	115	3770

**Note:** In addition to the 3770 Roland 2 missiles of option 5, Germany has ordered 1030 Roland 3 missiles for its Air Force.

In November 1986 the Qatari Army placed an order for three batteries of three fire units each. One battery uses the AMX-30 chassis version whilst the other two use the shelter type. Deliveries and equipment training were completed in 1989.

In early 1991 the Roland (in both self-propelled and shelter form) was used by Iraq in the Gulf War against the Coalition Forces.

#### Description

The current Roland 2 SAM system has been designed to engage enemy aircraft flying at Mach 1.2 or less between a minimum altitude of 10 m and a maximum altitude of 5500 m and between a minimum effective range of 500 m and a maximum range of 6300 m. The system has two modes of operation; optical and radar with possible switching from one to the other during an engagement. In both cases the target is first detected by the pulse Doppler Siemens MPDR-16 D-band surveillance radar which rotates at 60 rpm and automatically suppresses fixed echoes. The radar scanner, which can be operated while the vehicle is travelling, has an acquisition range of 1.5 to 16.5 km for a 1 m<sup>2</sup> target operating between speeds of

50-450 m/s and can be folded down behind the turret rear for transport. The radar is capable of detecting hovering helicopters. Once the target has been detected it is interrogated by either a Siemens MSR-400/5 (German vehicles) or an LMT NRAI-6A (French vehicles) IFF system, acquired and then either tracked by the tracking radar (in the radar mode) or by the operator using the optical sight (optical mode).

In the optical mode the missile is slaved to the line-of-sight of the operator in the following manner. The sight measures the angular velocity of the target and the infra-red localiser determines the deviation of the missile in relation to the line-of-sight. Using this data the computer calculates the required guidance commands which are then transmitted to the missile by a radio command link. The signals received by the missile are then converted into jet-deflection orders.

In the radar mode at the tracking stage the radar beam is slaved to follow the target by misalignment, voltage signals originating from the radar target tracking channel. The tracking radar, mounted on the front of the turret, is a two-channel, monopulse Doppler microwave Thomson-CSF Domino 30 system; one channel tracks the target and the second locks in on a microwave source on the missile.

After launch an infra-red localiser on the antenna of the tracking radar is used to capture the missile within a distance of 500 to 700 m, at which range the missile has entered the pencil beam of the tracking radar. A second tracking channel follows the missile by means of a transponder carried on it. Missile deviation is calculated from the angular deviation between target/antenna and antenna/missile. The deviation information is supplied to the computer and from then on the operation of the guidance loop is the same as that of the optical mode.

It is possible to switch from optical to radar guidance mode, or vice versa, in both the target pursuit and firing modes. This facility significantly increases the resistance of the Rolands to jamming in either mode.

The two-stage solid-propellant powered missile itself has a launch weight of 66.5 kg, of which the hollow-charge warhead weighs 6.5 kg, including 3.3 kg of explosive which is detonated either by impact or a TRT electromagnetic continuous-wave radar type proximity fuze. Maximum lethal radius of the warhead's 65 projectile charges is approximately 6 m plus from the detonation point. The missile has a cruising speed of Mach 1.6, an overall length of 2.4 m, wing span of 0.5 m and a body diameter of 0.16 m. It is delivered in its container which also serves as a launcher tube. The complete container (including the missile) weighs 85 kg, is 2.6 m long and has a diameter of 0.27 m.

The 1.7 second burn 1600 kg thrust SNPE Roubaix boost rocket motor is of the extruded double-base solid propellant type and accelerates the missile to 500 m/s. The 200 kg thrust 13.2 seconds burn SNPE Lampyre sustainer rocket motor, located in front of the boost motor, then cuts in 0.3 seconds after booster burn out with its cast double-base solid propellant fuel to maintain the speed until main motor burn out. Minimum flight time required by the weapon to arm itself is 2.2 seconds with the maximum flight time around the 13-15 second mark.

Two missiles are carried ready to launch and another eight are carried in two revolver type magazines each of which holds four rounds.

An improved missile, Roland 3, with increased speed (570 m/s compared to 500 m/s) and range (8 km compared to 6.3 km) entered service in 1989. The new missile has a 9.2 kg warhead which contains 5 kg of explosives and 84 projectile charges to increase its lethality without any change in its dimensions.

An improved proximity fuze coupled with a new 5000 m/s maximum velocity fragmentation pattern (over 2.5 times the Roland 2 warhead fragment





Country	Quantity	User	Comment
Qatar	3 + 6	army	3 Roland 2 on AMX-30 chassis, 6 Roland 2 on MAN 8 x 8 chassis
Spain	18	army	Roland co-production, AMX-30 chassis, first delivery November 1988
USA	27	air force	Roland 2, 8 x 8 chassis, German manned
Venezuela	6	army	Roland 2, shelter version

\* Numbers reduced due to combat losses in Gulf War against Coalition Forces in 1991.

**Manufacturers:** Aerospatiale, France and MBB, Germany.

Marketing and sales are handled by Euromissile, 12 rue de la Redoute, F-92260 Fontenay-Aux-Roses, France.

Telephone: (1) 46 61 73 11

Telex: EUROM 204691 F

Fax: (1) 46 61 64 67

Associated contractors in Spain are INISEL, Mar Egeo, s/n, Poligono Industrial No 1, San Fernando de Henares; Empresa Nacional Santa Barbara SA, Manuel Cortina 2, E-28010 Madrid; and CESEL SA, Paseo de la Castellana 143-60, PO Box 36189, E-28046 Madrid.

## Euromissile Polyphem Low Altitude Anti-helicopter Missile System

### Development/Description

Following initial work in 1982-84, the Polyphem fibre optic guided weapon system concept was formulated by the Euromissile team. Besides an anti-helicopter version with a range of more than 10 000 m the system can also be used in the surface-to-surface role in both light and heavy artillery configuration. The latter can utilise a heavy truck or tank chassis, with 36 missiles available and a weapon range of more than 25 000 m. For armoured infantry or the tank destroyer role a light truck with six missiles and a range of more than 10 000 m is considered adequate, whilst for airborne troops six helicopter loadable missiles with a range of more than 10 000 m is envisaged. There is also an anti-aircraft/anti-helicopter version for over-the-horizon targeting situations by submarines. All the Polyphem versions can also be used for terrain reconnaissance as part of their normal attack flight profile.

The first launch of a Polyphem feasibility demonstrator missile occurred in December 1987. The weapon was a modified Aerospatiale AS-12 anti-ship missile which carried a fibre optics cable spool and a CCD-TV seeker. A further three launches in 1988 proved that the missile could be successfully guided over ranges up to 7000 m at a cruise altitude of 160 m and a speed of about 150 m/s using the fibre optic guidance and a controlling ground station for the gunner.

A pre-production version of an operational system is currently under evaluation by the German and French MoDs. The programme was started in March 1991 under a French/German co-ordinated contract. The operational system will be equipped with an IR seeker and a turbine engine to provide the gunner with a variable speed capability around the 150 m/s region. When engaging a helicopter the weapon has the capacity to endure up to 10 g sustained manoeuvring.

The Polyphem system will comprise a number of boxed missile container-launchers and a firing post. The latter will have the operator's firing controls, a real-time image processor, Visual Display Unit (VDU) and system computer to provide: the real-time imagery from the IR seeker; automatic target detection; threat evaluation and information on a set of possible targets to engage. A salvo series firing capability allows the gunner to send several



*Polyphem demonstration missile based on modified AS-12 anti-ship missile airframe*

missiles along the same initial flight trajectory and when they enter the designated target area assign them their own individual targets. Once a target is acquired and selected by the operator the terminal tracking/homing phase is entirely automatic.

**Status:** Development phase.

**Manufacturers:** MBB, Germany and Aerospatiale, France.

Enquiries to: Euromissile, 12 rue de la Redoute, F-92260 Fontenay-Aux-Roses, France.

Telephone: (1) 46 61 73 11

Telex: EUROM 204691 F

Fax: (1) 46 61 64 67

## Shorts/Boeing Starstreak Avenger Pedestal-Mounted Self-propelled Air Defence System

### Development/Description

As part of the ongoing development of its Avenger Pedestal-Mounted Stinger (PMS) system the Boeing Company, Defense and Space Group's Huntsville Division has teamed with Shorts Brothers PLC of Belfast to adapt the Shorts Starstreak Hyper Velocity Missile (HVM) Close Air Defence Weapon System for use with the system.

This combination is to be offered in 1992 for evaluation as an off-the-shelf product improvement to the US Army for its current Forward Area Air Defense System Line-of-Sight-Rear (FAADS-LOS-R) Stinger PMS fleet.

In mid-1990 initial trials of the first four-round Starstreak pod integration were carried out, and in mid-1991 a successful proof-of-principle test was carried out in Scotland with guided weapons using prototype fire control electronics and associated software. The tests are being followed by a full-scale integration phase which will involve firings of both Starstreak and Stinger missiles using a model with all the Starstreak functions fully integrated into the Avenger's fire control system. These include modifications to the Avenger's software algorithms, electronics interfaces and electro-optics so that Avenger is fully capable of automatically guiding a Starstreak to the target. For example, the Avenger's tracking accuracy has been improved to suit Starstreak's characteristics and a laser guidance unit has been added.



*Guided firing of the Shorts Starstreak high velocity missile from a Boeing Avenger system*



An Avenger prototype shows how the Starstreak high velocity missile will be integrated with the Stinger missile in the Avenger turret. The four Starstreak missiles are housed in the right pod and the four Stinger missiles in the left pod (looking from the front)

The testing programme is designed to eliminate the major areas of technical risk; Starstreak launch motor blast effects, servo and electro-optical integration on the Avenger system and compatibility of Starstreak with the system sensors.

The addition of the Starstreak HVM is intended both to complement the Stinger missile characteristics and enhance the overall systems capability against rotary-wing aircraft in ground clutter such as trees, foliage, terrain and man-made structures.

It also provides the Avenger system with significant capabilities in the ground role against light armoured vehicles.

A full description of the Avenger PMS can be found in this section under USA and of the Starstreak HVM in the *Manportable Surface-to-air Missile* section.

**Status:** Development.

**Manufacturers:** Enquiries to.

The Boeing Company, Boeing Defense & Space Group, PO Box 240002, MS JW-49 Huntsville, Alabama 35824-6402.

Telephone: (205) 461-2805

Shorts Brothers PLC, PO Box 241, Airport Road, Belfast, BT3 9DZ, Northern Ireland.

Telephone: (0232) 458444

Telex: 74688

Fax: (0232) 454406 or 732974

## Oerlikon-Contraves ADATS Missile System

### Development

Based on an analysis of threat projections, Oerlikon-Contraves began studies on a cost-effective modular missile system which has a high lethality against both air and ground targets. In 1979 Oerlikon began developing such a system under the trade name ADATS, after selecting Martin Marietta as prime subcontractor. In June 1981 the first Ballistic flight of the missile took place at the White Sands Missile Range, New Mexico. Trials of the complete system started in 1982 and development was completed in August 1984. Two prototypes were built on the M113A2 APC chassis and have been used for further tests and evaluation.

Worldwide (USA excluded), ADATS is marketed by Oerlikon-Contraves, whereas Martin Marietta markets it in the USA. The system final assembly and integration tests take place at the sister company, Oerlikon-Aerospace Inc, Canada. Main subcontractors are Italiana and Litton Canada (radar), Martin Marietta (EO module, missile), Litton Systems Canada (electronics), FMC, USA (M113 series tracked vehicle) and Oerlikon-Contraves, Switzerland (turret and CO<sup>2</sup> laser). Oerlikon-Contraves has overall responsibility for the ADATS missile system as well as production of the missiles.

The Swiss Army tested ADATS in 1984 and 1985. In June 1986 the Canadian Forces selected ADATS as part of the system to meet its requirement for a Low Level Air Defence (LLAD) system.

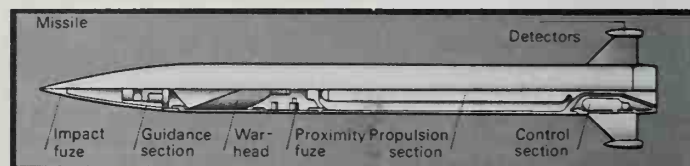
The order comprised 36 ADATS systems, 20 Oerlikon-Contraves GDF-005 twin 35 mm cannon and 10 Skyguard fire control systems with the first units being delivered in 1988.



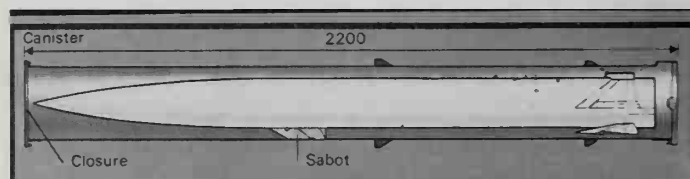
ADATS on FMC M3 Bradley chassis with missiles elevated ready to engage target



ADATS on FMC M3 Bradley chassis launching missile



ADATS missile



ADATS missile in its container-launcher





*Launching of ADATS missile*

The first four ADATS units (nicknamed 'Pathfinder' by the Canadian Armed Forces (CAF) and mounted on modified M113A2 APC chassis) were delivered to the CAF Low Level Air Defence School at Chatham, New Brunswick in October 1988. By September 1991 all of the twin 35 mm anti-aircraft guns, all of the Skyguard fire control systems and six of the ADATS systems had been delivered to the Canadian Forces.

Control of the CAF's battlefield low level air defence assets in Europe has been assigned to the newly raised 4th Air Defence Regiment. This has command of the following sub-units:

- (a) 127th Air Defence battery at Baden with four Skyguards, eight GDF-005 guns and four ADATS to protect the McDonnell Douglas CF-18 Hornet equipped air base
- (b) 128th Air Defence Battery at Lahr with similar equipment to the 127th battery to protect the CF-18 air base
- (c) 129th Air Defence Battery at Baden with 12 ADATS with 15 Blowpipe launchers for deployment with units of the 1st Canadian Division in the field.

In addition there is the 119th (Independent) Air Defence Battery at Chatham with 12 ADATS and 15 Blowpipe launchers available in the reinforcement role. The remaining GDF-005 guns and Skyguard fire control systems and ADATS are for training use.

The whole Canadian CF-LLADS network was due to be operational by the end of 1991. In that year it was stated that the Canadian Forces presence in Europe were to be reduced, the two air bases would be closed and aircraft and air defence assets were to be returned to Canada by the mid-1990s.

Martin Marietta/Oerlikon-Contraves supplied two ADATS systems for trials in the USA in the Summer of 1987 to meet the US Army requirement for the FAAD-LOS-FH system. The British Aerospace Tracked Rapier, Thomson-CSF Shahine and the Euromissile Roland were all modified in a number of areas and supported by a US partner for this competition.

In November 1987 the US Army announced that Martin Marietta, under contract with the Oerlikon-Contraves of Switzerland, had been selected as the winner of the FAAD-LOS-FH system. Four ADATS units were purchased with FY88 funds for use in extensive operational tests in 1989-90 before a final decision was made to go into full production.



*Interior view of ADATS fire unit showing operator's controls and displays*

The 1991 budget sought \$271.8 million for 15 fire units and 220 missiles. However, in September 1990 it was announced that the ADATS procurement programme was being delayed for two years to allow reliability problems with the system to be corrected. Operational certification will also be concurrently delayed until early 1992.

Total procurement of ADATS by the US Army was projected at 566 (including the four trials fire units) systems, each equipped with 18 missiles. Oerlikon Aerospace will provide the first 60 fire units and 1000 missiles while Martin Marietta will build the remaining fire units and missiles as well as the electro-optics for all fire units. The electro-optical units will be built at Martin's facility in Orlando, Florida, while the missiles will be built at a facility in Ocala, Florida. The total cost of this programme is estimated at \$12 billion. In the same time period as the programme delay announcement the US Army reduced its expected buy of ADATS to approximately 380 systems.

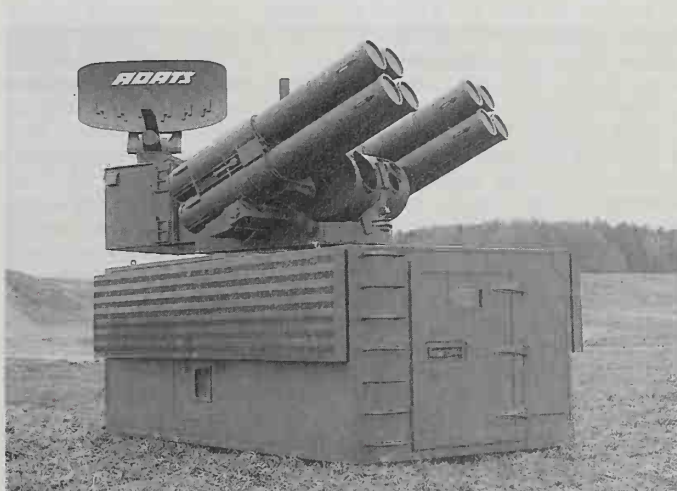
#### **Description**

The ADATS consists of a 360° traversable turret fitted with a surveillance radar, 8-12  $\mu$ m wavelength forward looking infra-red (FLIR) and TV trackers, a Nd:YAG laser rangefinder and a carbon dioxide (CO<sub>2</sub>) missile guidance laser. Four missile launcher-containers are carried either side of the turret. Two control consoles, one for the radar operator and the other for the electro-optics (gunner) operator are placed inside the carrier vehicle.

Airborne targets are detected by a fully coherent I/J-band pulse Doppler frequency-agile dual-beam SHORAR surveillance and acquisition radar supplied by Contraves Italiana, the antenna of which rotates 360° and is capable of detecting targets from very low levels up to 6000 m altitude at ranges of over 24 km. An integrated IFF set is associated with the radar which is also capable of displaying track information on up to 10 prioritised targets on the radar operator's PPI display. Output of the FLIR and/or TV sensor systems appears on the display which is operated by the electro-optics operator. Once a target is designated as hostile by the radar operator the turret is automatically slewed round to its bearing and a search is initiated to bring it into the field-of-view of the FLIR (5.4 × 7.2° wide field-of-view, 2 × 2.6° narrow field-of-view) or TV camera (2.4 × 3.2° wide field-of-view, 0.5 × 0.7° narrow field-of-view) which are installed in a bin on the front of the turret. The electro-optics operator then selects either the FLIR or TV



*ADATS system of the Canadian Forces on a modified M113A2 series APC chassis*



*Prototype of shelter-mounted ADATS system*

for tracking depending on the light level and prevailing weather conditions. The selected sensor then 'locks-on' to the target and begins automatic tracking. The range is measured either by the Nd:YAG laser rangefinder or is provided by the track-while-scan facility of the surveillance radar to ensure that the target is within engagement range. A missile is then launched and guided by a 10.6  $\mu\text{m}$  wavelength coded pulse CO<sub>2</sub> laser to the target.

The Mach 3 plus smokeless propellant missile itself is 2.057 m long, 0.152 m in diameter and weighs 51.4 kg. The dual purpose warhead carried weighs 12.5 kg with the casing providing a fragmentation effect against aircraft. The missile warhead can penetrate around 100 cm of steel armour. The minimum and maximum ranges for air targets up to 6000 m altitude are 1000 and 10 000 m respectively and against armour targets the minimum and maximum ranges are 500 and 8000 m. The missile is fitted with an impact fuze and an electro-optical laser proximity fuze for air targets. The launcher-containers are 2.2 m long, 0.24 m in diameter and weigh about 65 kg loaded and 13 kg empty. The missile launchers can be elevated from -9 to +85° for missile launch; intercept is guaranteed up to 90°.

Ground targets are acquired electro-optically and the range is determined by the laser rangefinder. The remainder of the engagement sequence is as for the air target.

#### Variants

In addition to being installed on an M113A2/M113A3 or M3 Bradley chassis, ADATS could also be installed on other tracked and wheeled chassis, including the MOWAG Shark (8 x 8), Warrior IFV and the Italian IVECO B1 Centauro (8 x 8) developed for the Italian Army.

A prototype of a shelter-mounted version of the ADATS system was completed in 1990.

For the shelter version Oerlikon-Contraves is working with Fokker who have considerable experience in this field. This version would have the

same turret as the basic self-propelled ADATS system and can be carried on the rear of a 7 t truck or equipped with mobilisers to convert it into a trailer. The company is also proposing a combined gun/missile battery which would have one Skyguard trailer-mounted fire control system, two twin 35 mm Oerlikon-Contraves towed anti-aircraft guns and a shelter-mounted ADATS system without its surveillance radar.

**Status:** In production. In service with Canadian Forces, selected for US Army and will enter production after final acceptance and reliability trials.

**Manufacturer:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.

Telephone: (01) 306 22 11

Telex: 823 402 coz ch

Fax: (01) 301 34 66



ADATS missile in flying configuration

## South Korea-USA Low Altitude Mobile Surface-to-air Missile Programme

#### Development/Description

In June 1989 the USA and South Korea signed a Memorandum of Understanding (MoU) covering the co-operative research and development programme for guidance technology associated with a 10 000 m plus short-range low altitude mobile SAM system optimised for use in the South Korean peninsula region.

The initial project work involves three concept validation phases in the laboratory; 12 months for analysis, 18 months for seeker design and 6

months for test and integration. If this is successful the next step will be the production of prototypes.

The SAM system is aimed at being more sophisticated and larger than the current US Stinger weapon and will be deployed on a vehicle-mounted platform. Service introduction is expected to be in the mid-1990s.

The major problem area foreseen and addressed by the MoU is how to switch the missile guidance from Command to Line-of-Sight (CLOS) mode to a terminal homing seeker system when the missile is out of sight. One possible solution to be explored is the utilisation of state-of-the-art infra-red technology.

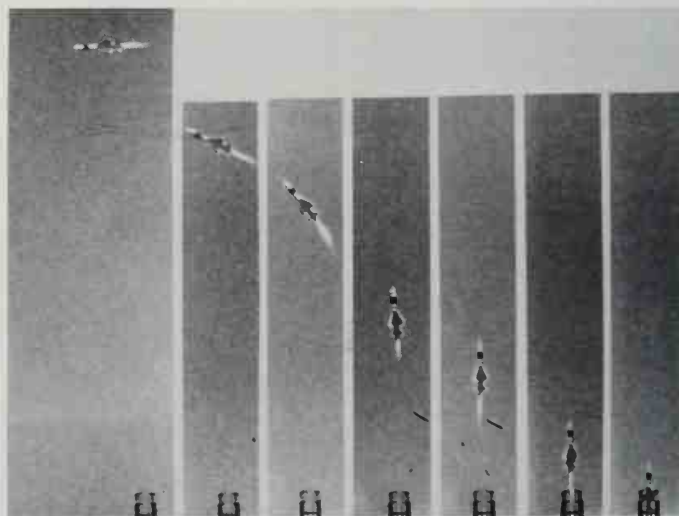
**Status:** Concept validation phase for seeker technology.

## ISRAEL

## Rafael ADAMS Vertical Launch Low Altitude Surface-to-air Missile System

#### Development/Description

The ADAMS (Air Defence Advanced Mobile System) vertical launch surface-to-air missile system is designed for fitting on vehicles such as the LAV-25, M2 Bradley IFV MAN 8 x 8 truck, as a Shelter system or simple ground-launcher configurations featuring 8, 12, 16 or more missiles. Each lightweight canister-launcher occupies an area of only 0.1 m<sup>2</sup> per missile. The vertical launch configuration allows for an immediate 360° coverage around the launcher without the need for time consuming mechanical aiming required by more traditional launch methods. A pulse Doppler search radar is fitted to the larger launchers to provide all the necessary data for the missile's guidance radar. The search radar can track up to 20 targets while still scanning for new contacts and has the ability to track targets operating within the speed range of Mach 0.3 to 3. These are interrogated by an IFF system and handed over to the guidance radar if hostile. The guidance radar is actually of the search-track-guidance type but has been optimised for use in the last two modes. Operating in the I/J and K-bands it provides target position and command-to-line-of-sight data for the Barak missile used in the system. Alternatively for use in a heavy ECM environment electro-optical guidance can be fitted, although both can be used at the same time to guide missiles to two separate targets. The Barak is stored in the 300 x 350 x 2500 mm launcher tube with its wings folded and is practically maintenance free. Missile length is 2.175 m, diameter 0.17 m and wing span 0.684 m. Maximum speed is over Mach 2.0. It weighs 88 kg and has an HE warhead weighing 22 kg with a sophisticated laser proximity fuze system. The minimum engagement range is 500 m, the maximum is 12 000 m. Altitude limits are from very low to a maximum of 10 000 m. A key



Sequence of photographs taken during Barak trials showing vertical launch and leanover manoeuvre

feature of the missile is that 0.6 seconds into the flight, it is able to vector over to as low as 25° below the horizon or as much as 85° above the horizon. It does this by using the rocket motor's virtually smokeless lower thrust setting and jettisonable thrust-vector control fins in the rocket efflux.





*Vertical launch of Barak missile during trials*

In order to engage an incoming target, it uses high acceleration rocket boost mode, aerodynamic flight control fins and the motor in its final sustained thrust mode for high manoeuvrability.

In 1987 it was announced that trials had confirmed the missiles vertical launch facility and achieved a direct hit during the intercept of a TOW ATGW. The interception test was conducted with the TOW ATGW emulating an incoming skimmer missile.

#### **Variant**

The ADAMS system is also associated with the High Value Site Defense (HVSD) hybrid gun/missile system being offered by General Dynamics, Valley Systems Division and Rafael (qv Self-Propelled Anti-aircraft Guns Section).

**Status:** Barak is entering production. The missile has been sold to three countries — Chile, Singapore and Taiwan (all believed to be naval systems).

**Manufacturer:** Enquiries to Rafael, PO Box 2082, Haifa, Israel.

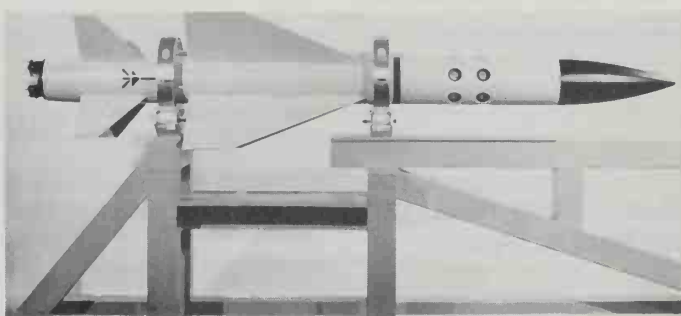
Telephone: (04) 706965

Telex: 471508 VERED IL

Fax: (04) 794657



*Artist's impression of self-contained ADAMS on a 8x8 truck chassis with one missile intercepting target and one missile being launched*



*Barak missile as used in ADAMS vertical launch low altitude surface-to-air missile system*

## **SOUTH AFRICA**

### **Cactus Low Altitude Surface-to-air Missile System**

#### **Development/Description**

The Cactus is the South African name for the French Thomson-CSF/Matra Crotale low altitude surface-to-air missile system. It was developed to meet the requirements of South Africa following the British Government's refusal to supply South Africa with surface-to-air missiles in 1964. Full details of the system are given in the Crotale entry in the French section. South Africa took delivery of seven acquisition and 14 fire units which are used by the South African Air Force for air base defence.

The Cactus system was used operationally by the South African Air Force during the Angola operations of 1988. Codenamed Operation Arno, a small

air defence detachment equipped with two Cactus launchers, several 23 mm ZU-23 anti-aircraft guns and a number of SA-7 'Grail' manportable SAMS deployed in February 1988 to the Cuito Cuanavale — Chaminga region of Southern Angola where the unit took part in three separate Cactus engagements against Angolan Air Force MiG-21/MiG-23s. A total of four missiles were fired with one exploding sufficiently near a MiG-21 to seriously damage its main hydraulic system, the aircraft subsequently recovered safely to its base.

As a result of operational assessments of this operation and the perceived need to upgrade the Cactus system, the South African Air Force is undertaking a rebuild programme. Amongst the modifications being considered are the conversion of the mobile Cactus acquisition and fire units into shelter-based units and the adoption of an indigenous missile suitable for use with the fire control and radar elements of Cactus.

## Kentron Strela-1 (SAM-9) Self-propelled Anti-aircraft Missile System Upgrade

### Development/Description

As a direct result of the South African Ground Forces capture of Soviet SA-9 'Gaskin' and SA-13 'Gopher' air defence systems in the Angola conflict, Kentron has been able to develop a cost-effective upgrade package for the SA-9 system. The upgrade programme integrates the SA-13 (Strela-10) missile onto the SA-9 BRDM-2 transporter erector launcher (TEL).

This enables the battlefield features of both missiles to be utilised to the full by allowing the cheaper Strela-1 (9M31M version) to be used against the 'easier' targets and the more expensive and sophisticated Strela-10 (9M37M version - although Kentron indicates the Soviet Industrial missile designation is 9P31M) against the 'difficult' targets.

Only minimal and simple modifications are required to convert the TEL and its test equipment to carry and fire the SA-13. The missile mix also allows a choice of infra-red (IR) seeker types on the missiles for use against extremely low altitude targets as well as in adverse weather conditions. The

normal load is two SA-9 container-launchers on the inner rail stations and two SA-13 container-launchers on the outer rail stations. The designated missile type stations are not interchangeable. A maximum of two SA-13 or two SA-9 or one SA-13 and one SA-9 container-launcher box reloads are also carried.

Comparison of the missile characteristics are given below:

MISSILE	STRELA-1 (9M31M)	STRELA-10 (9M37M)
WEIGHTS		
missile in container-		
launcher box	53.4 kg	70.2 kg
missile	30 kg	39.5 kg
DIMENSIONS		
container-launcher box	1900 × 290 × 290 mm	2330 × 290 × 290 mm
GUIDANCE	optical aiming	optical aiming
IR SEEKER TYPES	uncooled lead sulphide (PbS)	uncooled lead sulphide (PbS)
	near-IR homing type with no counter-measures	near-IR homing type with counter-countermeasures capability against IR decoys or cooled indium antimonide (InSb)
		mid-IR homing type with counter-countermeasures capability against IR decoys
CONTROL METHOD	four movable canards and four rotor-controlled surfaces for roll stabilisation	
WARHEAD	2.6 kg HE-controlled fragmentation (430 fragments)	2.7 kg HE-fragmentation rod (100 rods)
LETHAL RADIUS	5 m	5 m
FUZING	impact and active xenon lamp proximity	
MAX MISSILE SPEED	Mach 1.5	Mach 2
MAX TARGET SPEED	300 m/s	420 m/s

Status: Ready for production.

Manufacturers: BRDM-2 TEL and missiles — Soviet state factories.  
Upgrade package — Kentron, enquiries to:  
Armcor, Private Bag X337, Pretoria 0001, South Africa.  
Telephone: (012) 428-1911  
Telex: 320217



Standard SA-9 system upgraded by Kentron and fitted with SA-9 SAMs inboard and SA-13 SAMs outboard

## SWEDEN

### Bofors RBS 70/M113 Low Altitude Surface-to-air Missile System

#### Development

In March 1988 Bofors announced that it had test fired its latest vehicle-mounted application of the RBS 70 missile system, the RBS 70/M113 combination.

Designed to meet a Pakistan Army requirement for a mobile SAM system to protect mechanised units in the field the conversion has gone into production in Pakistan. Pakistan also manufactures some parts of the RBS 70 missile under licence.

The missile system is transported in a folded down state to present the M113 as a 'normal' APC and conceal its air defence role from overhead observers. Once in a combat situation and assigned a fire mission the system is raised to its operating position as described below.

#### Description

The M113 variant chosen by Pakistan for the conversion is the M113A2. The operating crew consists of four; the fire (and vehicle) commander, missile operator, loader/radio operator and vehicle driver.

The latter sits at the front of the all-welded aluminium hull on the left side and has a single-piece hatch cover that opens to the rear. To his right is the engine compartment with the fire commander seated to his rear in the centre front of the troop compartment. Above him is a cupola which can traverse through 360° and mount a 12.7 mm calibre heavy machine gun.

To his immediate left on the crew compartment wall and above a bank of two radio transceiver sets is the Target Data Receiver (TDR). This is connected to one of the radios and provides the combat control information



Armoured (4 × 2) tractor of the Pakistani Army carrying Bofors RBS 70 surface-to-air missile system

and target data from an external surveillance radar required for an engagement.

The loader/radio operator sits adjacent these electronic units on a foldable seat with the missile operator alongside him. Both face inwards





Bofors RBS 70/M113 SAM system ready to engage target

and look directly at the RBS 70 missile platform which is hinged to the compartment roof on its right side and held upright in the travelling position by two torsion springs. Behind this and on the vehicle's right wall, overhanging the track, is the missile store for six RBS 70 standard container-launcher tubes.

In normal mobile combat situations the fire commander receives a radio alert from his parent unit's Tactical Control Officer. This causes him to order both the vehicle driver to stop on a level piece of ground and the other crew members to assume their battle positions. The loader releases the crew compartment's rectangular two-piece foldable roof hatch and moves it to the open left position. He then releases the springs on the missile platform and, together with the missile operator, swings the unit upwards to act as the compartment's roof. The platform is automatically locked and secured in position.

The fire commander enters the vehicle's co-ordinates and reference North into the TDR if they have not already been set before deployment. The missile operator leaves the vehicle via the rear power-operated ramp and climbs onto the missile platform where he releases the lock of the missile hatch located over the top of the missile store and assembles the RBS 70 launcher stand from its components.

In the meantime the driver moves from the front of the vehicle to assist the loader who is preparing the first two missile containers inside the store for use. He removes the front end cap of the immediate ready-to-use round and the missile operator lifts this container up through the missile hatch, fits it onto the launcher stand and removes the rear end cap. The operator then closes the missile hatch and positions himself on the stand's seat where he connects up his intra-vehicle headphone communications unit and makes the system ready for firing. Inside the vehicle the loader prepares and positions the next missile container-launcher for use under the hatch cover.

The fire commander and missile operator orientate the RBS 70 fire unit to the TDR and the former reports that the fire unit is ready for combat. When a target is assigned over the TDR the missile operator slews the stand to the actual target bearing and starts a target engagement of the type described in the *Manportable surface-to-air missile* section RBS 70 entry. Final permission to fire is given by the fire commander when the target is in effective range.

Once the engagement is concluded, the commander can order the missile operator and loader to reload the system. The operator locks the RBS 70 sight in elevation, discards the empty missile tube and repeats the loading sequence described above but without disconnecting his headphone.

If disengagement or redeployment is required then the reverse of the operating sequence is followed to secure the vehicle for travelling.

The vehicle also carries a standard RBS 70 field stand for deploying the fire unit independently. For close-to-the-vehicle operations this must be within a 40 m radius and the fire commander decides upon the site to be used. The missile platform is deployed as for the mobile engagement mode in order for the missile operator to remove the sighting unit. The loader simultaneously removes the field stand from the vehicle and positions it at the designated site. The complete assembly is erected and a missile container attached. A signal cable is run from the vehicle to the field stand and the transceivers in the vehicle are connected to the TDR by twin cable. The fire commander then connects the field stand cable to his TDR and checks with the missile operator that the cable link is functioning. If correct the missile operator reports that he is in the ready to fire state.

In the case of operations which are further than 40 m from the vehicle because it has had to be abandoned, or it cannot be located in or near to the commander's designated site, then all the portable RBS 70 equipment is unloaded, namely the sight unit, field stand, the six missile containers, two radio transceivers, TDR with its signal cables and the systems accessories box. The deployment sequence then becomes the same as for the manportable RBS 70.

#### SPECIFICATIONS

CREW	4
COMBAT WEIGHT	11 600 kg
LENGTH	4.863 m
WIDTH	2.686 m
HEIGHT	
transport mode	2.04 m
deployed mode	3.44 m
MAX SPEED	
cross-country	23 km/h
road	67 km/h
FORDING	amphibious
VERTICAL OBSTACLE	0.61 m
GRADIENT	60%
TRENCH	1.68 m
ENGINE	Detroit Diesel Model 6V-53T 6-cylinder water-cooled diesel developing 275 bhp at 2800 rpm
TRANSMISSION	Allison TX-100-1 with 3 forward and 1 reverse ranges
SUSPENSION	torsion bar
ELECTRICAL SYSTEM	24 V
ARMAMENT	1 × RBS 70 missile launcher
AMMUNITION	6 × RBS 70 missiles
ARMOUR	12 - 44 mm

**Status:** Production. In service with the Pakistan Army (locally produced conversion on M113A2 APC). It is also used by the Pakistani Army mounted on armoured 4 × 2 tractors which are also provided with two banks of electrically operated smoke dischargers firing over the frontal arc. Similar vehicles are used for other weapon systems.

**Manufacturers:** RBS 70/M113 conversion package: Swedish Ordnance (previously AB Bofors), Box 500, S-69180, Bofors, Sweden. Telephone: (46) 586 81000 Telex: 73210 BOFORS S Fax: (46) 586 581 45

M113 APC: FMC Corporation, Ground Systems Division, 881 Martin Avenue, Santa Clara, California 95052, USA. Telephone: (408) 289 0111 Telex: 6714210 Fax: (408) 289 2150

## Lvrbv 701 RBS 70 Low Altitude Surface-to-air Missile System

### Development

In February 1983, following the successful trials with a prototype vehicle, the Swedish Defense Material Administration awarded a contract to Hägglund and Söner (now Hägglunds Vehicle AB) for the conversion of a number of obsolete Ikv-102 and Ikv-103 self-propelled infantry cannon, which were withdrawn from the service some years ago, into Lvrbv 701 RBS 70 surface-to-air missile carriers. At the same time the company was awarded a contract to convert Ikv-103 chassis into Hughes TOW ATGW carriers.

First vehicles were delivered to the Swedish Army in 1984 and production continued to 1986.

The modifications have been extensive and include the replacement of the engine and transmission, extending the crew compartment, improving protection and fitting new communications equipment and observation devices.

The vehicles are organised into companies and deployed with both armoured and mechanised brigades. Radar warning is provided by vehicles equipped with the LM Ericsson Giraffe radar system, designated the PS-701/R.

### Description

The gun has been removed from the glacis plate and the position plated over. The driver sits at the front of the hull on the left side and has a single-piece hatch cover and fixed periscopes for observation to the front and sides. The commander sits to the right of the driver and has a single-piece



Bofors RBS 70 SAM just after it has left the launcher during trials in Sweden



Lrvbv 701 anti-aircraft vehicle with magazine for RBS 70 surface-to-air missiles raised, showing IFF system above RBS 70 launcher (FMV)



Lrvbv 701 anti-aircraft vehicle with Bofors RBS 70 surface-to-air missile system in operation position (FMV)

hatch cover which opens to the right rear and observation periscopes. The commander's position is raised above the driver to give improved observation.

In the centre of the hull roof is a large circular opening with a two-piece hatch cover that opens to either side. The Bofors RBS 70 surface-to-air missile system is carried inside the hull and raised up when required for action. The IFF system is mounted on the stand above the missile launcher tube. Reserve missiles are stowed in the hull rear above the engine and transmission compartment with access via the front edge of the magazine, which folds upwards.

The suspension, which is identical to that on the Ikv-102 and Ikv-103, consists of six rubber-tyred road wheels with the drive sprocket at the rear, idler at the front and two rack return rollers. The original engine has been replaced by a Ford V-6 petrol engine which is also installed in the Bv 206 all-terrain vehicle already in service with the Swedish Army.

The crew of four of the Type 701 consists of the commander, gunner, loader and driver.

#### SPECIFICATIONS

CREW	4
COMBAT WEIGHT	9700 kg
POWER-TO-WEIGHT RATIO	14 hp/t
GROUND PRESSURE	0.4 kg/cm <sup>2</sup>
LENGTH	4.81 m
WIDTH	2.54 m
WIDTH OVER TRACKS	2.23 m
HEIGHT	
missile system extended	2.89 m (inc IFF)
missile system extended	2.46 m (top of launcher)
system lowered into vehicle	2.07 m
GROUND CLEARANCE	0.33 m
TRACK	1.83 m
TRACK WIDTH	400 mm
LENGTH OF TRACK ON GROUND	3 m
MAX ROAD SPEED	
high range forwards	41 km/h
low range forwards	21 km/h
reverse	7 km/h
FUEL CAPACITY	240 l
MAX ROAD RANGE	300 km
FORDING	0.9 m
GRADIENT	60%
TRENCH	1.5 m
ENGINE	Ford Model 2658E V-6 petrol developing 136 hp at 5200 rpm
TRANSMISSION	Mercedes W 4A-018, 4 forward and 1 reverse gears
ARMAMENT	1 × RBS 70 SAM launcher
ELECTRICAL SYSTEM	24 V
BATTERIES	4 × 12 V, 57 Ah

**Status:** Production complete. In service with the Swedish Army.

**Manufacturer:** Hägglund Vehicles, S-891 01 Örnsköldsvik, Sweden.

Telephone: 0660 800 00

Telex: 6051 HAEGG S

Fax: 0660 826 49

## UNION OF SOVIET SOCIALIST REPUBLICS

### Soviet Laser Air Defence Weapons

According to the 1987 edition of *Soviet Military Power*, published by the US Department of Defense, the Soviet tactical laser programme has progressed

to the point where battlefield weapons could soon be deployed. No further details are available but both ground- and ship-based versions are understood to be involved. In the late 1970s a tactical laser weapon testbed was spotted near Golovino.



## SA-4 'Ganef' Medium to High Altitude Surface-to-air Missile System

### Development

The SA-4 'Ganef' (its US/NATO designations) medium to high altitude surface-to-air missile system's development began in the mid-1950s at the 'Antei' Scientific Industrial Organisation. It was first seen in public during a parade in Moscow in May 1964. Limited operational deployment began in 1967 but due to a number of major faults being found it was not fully deployed until 1969. The initial production variant was designated the 3M8, the later versions had the designations 9M8, 9M8M, 9M8M1 and 9M8M2. The system, known in the Soviet Army as the ZRD-SD (*Zenitniy Raketniy Kompleks — Srednoye Deistvie*: Anti-aircraft missile system — medium range) *Krug* (Russian for Circle) is now used by a number of armies. The system is air portable in the An-22 'Cock' aircraft.

The air defence elements for front, tank and combined arms armies included several SA-4 brigades (two for a Front, one for an Army). The 'Ganef' brigade consists of a brigade headquarters, three SAM battalions (each with nine ZU-23 twin 23 mm towed anti-aircraft gun systems) SSRTs (*Samokhodnaya Stantsiya Razvedki Tseleukazaniya*: mobile detection and designation radars nicknamed Long Track by NATO) and three 'Ganef' batteries and a technical battalion with one Long Track and one heightfinding Thin Skin radar. Each 'Ganef' battery in peacetime has one SSNR (*Samokhodnaya Stantsiya Navendeniya Raket*: mobile missile guidance station) radar nicknamed Pat Hand, three SA-4 SPU (*Samokhodnaya Puskovaya Ustanovka*: mobile launcher unit) launchers and four Ural-375 TZM (*Transportno-Zaryazhayushchaya Mashina*: transporter-loader vehicle) reload vehicles each with an integral crane to lift the single missile carried onto the SPU. Additional resupply missiles are carried by the missile technical battery singly on double-axle semi-trailers towed by ZIL-157V or ZIL-131V articulated tractors. On mobilisation for war a fourth launcher might be added to each battery. The 'Ganef' system is normally deployed between 10 and 25 km behind the FEBA and forms part of an overall air defence system incorporating SA-2, SA-6, SA-7, SA-8, SA-9, SA-11, SA-12a, SA-13, SA-14, SA-15, SA-16, SA-17 and SA-19 missiles and 23 mm, 30 mm and 57 mm anti-aircraft guns. The 'Ganef' is being replaced in Soviet service by a mix of SA-11 'Gadfly' and SA-12a 'Gladiator' brigades.

### Description

Each SPU (Soviet Industrial Index designation 2P24) consists of a tracked armoured chassis on top of which is mounted a hydraulically operated



Reload Ural-375 TZM (6 x 6) truck with integral crane carrying 9M8M1 variant Ganef missile

turntable carrying the two missiles. The chassis is a new design, not based on an existing vehicle. The driver is seated at the front of the vehicle on the left and has a single hatch cover in front of which are two periscopes. At the front of the glacis plate is a splash board to stop water rushing up the glacis plate when the vehicle is fording. The engine is to the right of the driver with the remainder of the space in the vehicle taken up by the crew and electronics. There are hatches for the other crew members either side of the missile turntable.

The torsion bar suspension consists of seven dual rubber-tyred road wheels with the drive sprocket at the front and the idler at the rear, and four track return rollers. Hydraulic shock absorbers are provided for the first and last road wheel stations. The vehicle has an air filtration and overpressure NBC system and an IR night vision system for the commander and driver but no amphibious capability.

The chassis has since been adopted for a number of other roles including the 152 mm 2S3 M-1973 self-propelled howitzer and minelaying. The latter model is called the GMZ and has the mines and minelaying equipment at the rear.

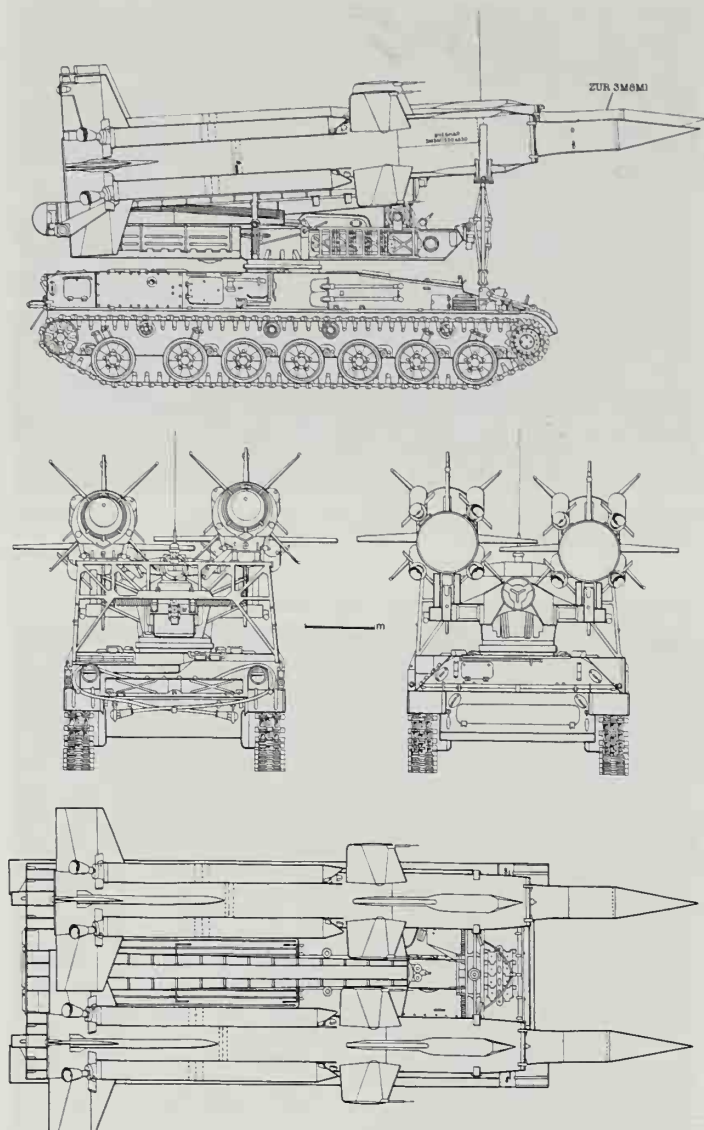
The launcher can be traversed by 360° with the missiles being elevated up to an angle of 45° on their launcher arms for launching. Before the missiles can be launched the rear vertical fins are replaced, the protective coverings of the ramjet air scoop and the various unit nozzles removed, the calliper clamps that hold each missile in the travelling position are released manually and the calliper frame folded forwards. The left missile is carried about 0.25 m above the right one. (Note: for transit purposes the rear vertical fins are removed).



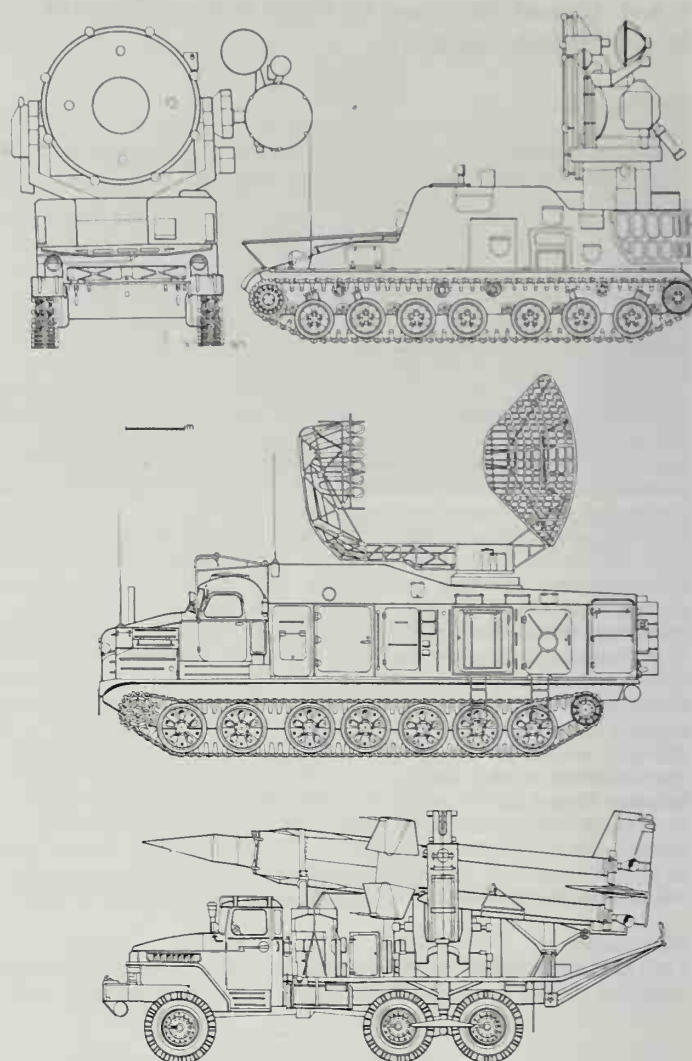
Long Track E-band surveillance radar on AT-T tracked chassis being prepared for rail transport. Note unditching beam carried at rear of hull



Pat Hand radar used with Ganef system



ZRK-SA (Krug) SA-4a Ganef surface-to-air missile system with two-round launcher traversed to front (not to 1/76th scale) (Steven Zaloga)



Other key components of the SA-4 Ganef air defence system (from top to bottom) include the Pat Hand missile guidance radar, Long Track surveillance radar and the TZM missile resupply vehicle on a Ural-375D (6 × 6) truck chassis. For rail transport the antenna of the radar systems is removed (not to 1/76th scale) (Steven Zaloga)



SA-4a Ganef system with 9M8M2 missiles and launcher elevated

The missile is launched by four solid booster rockets mounted externally on the body, in a similar manner to those mounted on the British Bloodhound SAM. After launch the boosters burn for about 15 seconds and then fall away when the fuelled ramjet kerosene sustainer motor ignition speed of over Mach 1 is attained at about 9 km from the SPU. The four fins are fixed and the four wings, in two pairs, are hydraulically operated.

A typical target engagement is believed to take place as follows. The target is first detected at long range by a 150 km range and 30 000 m maximum altitude Long Track early warning radar which is mounted on a lengthened version of the AT-T heavy artillery tractor with a large van body added and is also used for the SA-6 SAM. Long Track operates in the E-band and passes data to the SA-4 'Ganef' battery where the H-band Pat Hand continuous wave fire control and command guidance radar takes over. Height information is also provided by the 240 km range Thin Skin truck- or trailer-mounted heightfinder radar which operates in the H-band. The 2.44 m diameter Pat Hand radar is mounted on essentially the same chassis as the 'Ganef' launcher with the whole assembly collapsed flat and a grill raised in front of the radar for road transit. This radar acquires the target at about 120-130 km and when it is within the 80-90 km tracking range a single missile is launched and guided to the target by the guidance beam with a semi-active terminal homing phase for the final stage. The missile is tracked in flight by a continuous wave radar transponder beacon attached to one of the tail fins. The antennas fitted to the edge of the four forward wings are the semi-active guidance receivers for the terminal homing system. If required the Pat Hand can handle two missiles per target in order to increase the kill probability. The reserve missiles are carried on Ural-375 (6 × 6) trucks. Reloading the SPU takes between 10 and 15 minutes.





SA-4 Ganel launcher with missiles in travelling configuration

It is known that there have been as many as four sub-variants of the missile, designated 9M8, 9M8M, 9M8M1 and 9M8M2. External differences between them were minimal as any improvements were internal. The last two sub-variants are the predominant types in service. The 9M8M1 is the 1967 8.8 m long-nosed version (the SA-4a) with effective range limits of 8 to 55 km and effective altitude limits of 100 to 27 000 m. The 9M8M2, introduced in 1973, is the short-nosed 8.3 m version (SA-4b or 'Ganel' Mod 1). This has an improved close-range performance to reduce the dead zone above the SPU at the expense of losing some 3000 m in altitude and 5-10 km in maximum range capabilities. Both versions have a fuselage diameter of 0.86 m, a wing span of 2.3 m and a tail span of 2.73 m. The HE warhead weighs 135 kg and is detonated by a proximity fuze. The missile is armed 300 m from the launcher. The launch weight is estimated to be in the region of 2500 kg. A battery is likely to have one SPU fitted with the 9M8M2 and two SPUs with the 9M8M1 missile, although some SPUs have been seen carrying one missile of each type. An electro-optical fire control system is believed to be fitted for use in a heavy ECM environment.

#### SPECIFICATIONS

CREW	3-5
WEIGHT	30 000 kg
LENGTH	
with missiles	9.46 m
vehicle	7.5 m
WIDTH (of vehicle)	3.2 m
HEIGHT (with missiles)	4.472 m
GROUND CLEARANCE	0.44 m
TRACK	2.66 m



SA-4 'Ganel' missile being carried on a resupply trailer towed by a ZIL-157 6 x 6 cross-country truck

TRACK WIDTH	540 mm
LENGTH OF TRACK ON GROUND	5 m
MAX SPEED	45 km/h
FUEL CAPACITY	850 l
MAX RANGE	450 km
FORDING	1.5 m
GRADIENT	30%
VERTICAL OBSTACLE	1 m
TRENCH	2.5 m
ENGINE	Model V-59 V-12 water-cooled diesel developing 520 hp
MAX ARMOUR PROTECTION	15 mm
UNIT OF FIRE	2 missiles

**Status:** Production complete. In service with the following countries:

Country	Quantity	User
Bulgaria	27	army
Czechoslovakia	27	army
Hungary	18	army
USSR	1300	army

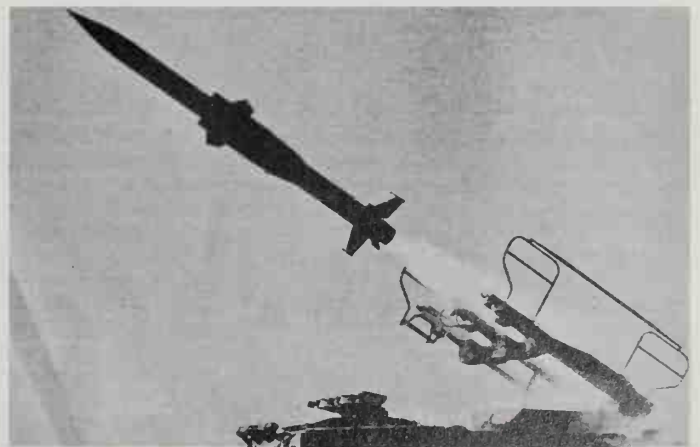
**Manufacturer:** 'Antey' Scientific Industrial Organisation  
**Enquiries to:** V/O 'AVIAEXPORT' 48 Ivan Franko Street, 121351 Moscow, Russian Republic.  
**Telephone:** 417-00-55  
**Cable:** Moscow, 351, Aviaexport  
**Telex:** 411929

## SA-6 'Gainful' Low to Medium Altitude Surface-to-air Missile System

#### Development

Development of the SA-6 'Gainful' (its US/NATO designations) low altitude surface-to-air missile system was begun by I I Toropov's OKB-134 design bureau at Tushino in 1959 but it was not seen in public until the 1967 Moscow Parade. The system, known as the ZRK-SD *Kub* (Russian for Cube) in the Soviet Army and ZRK-SD *Kvadrat* for export, entered full operational service in 1970 after a prolonged and troubled development and trials period. It is airportable in the An-22 and IL-76 aircraft. The missile industrial index number is 9M9 for the basic version.

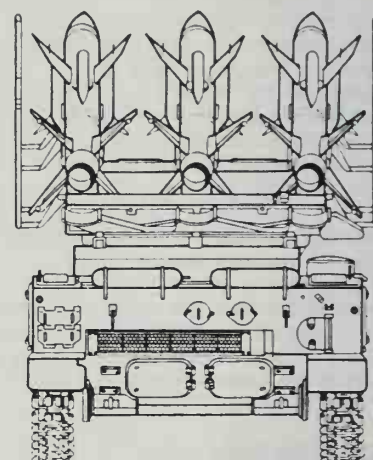
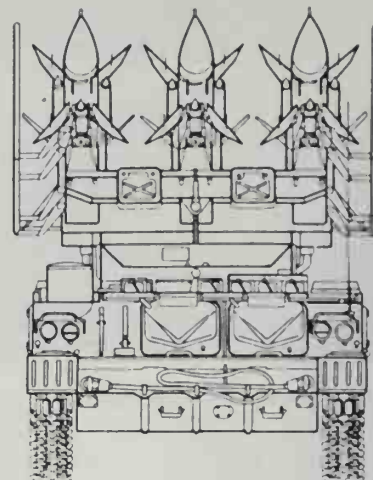
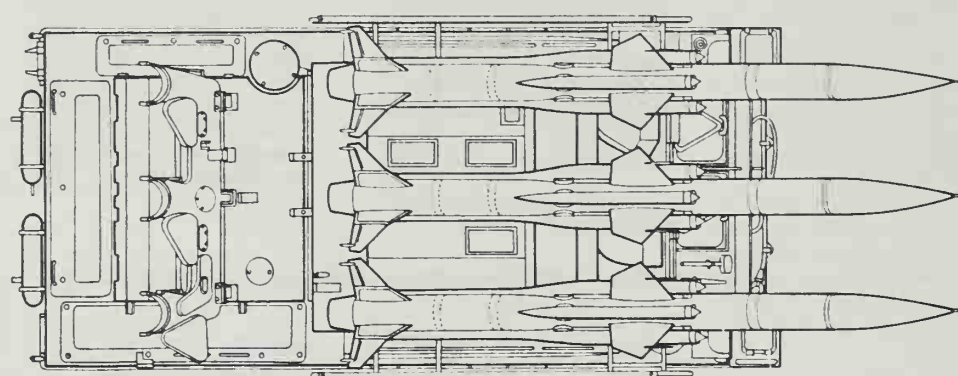
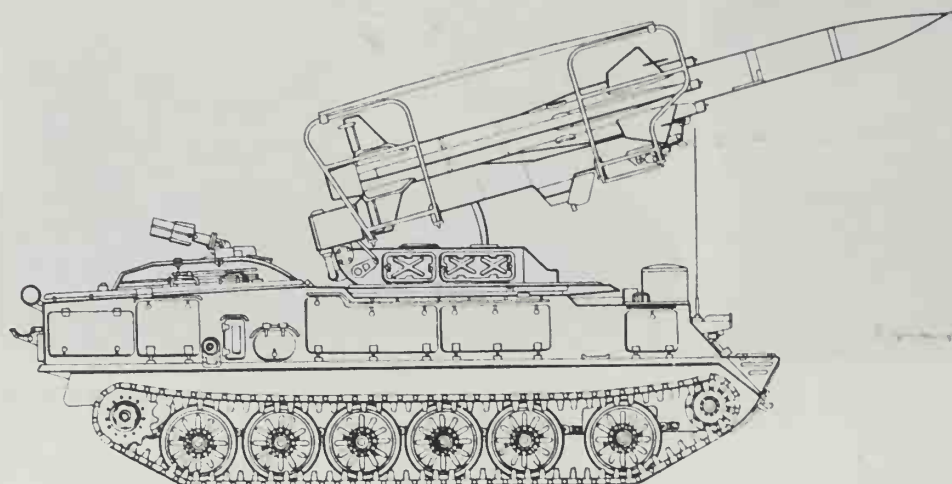
The first known use in action was during the 1973 Middle East war by Syria and Egypt when it proved highly effective against Israeli aircraft during the first few days of the war destroying approximately 20 aircraft of the Israeli Air Force, plus up to 40 Egyptian aircraft, 4 Iraqi aircraft and an unknown number of Syrian aircraft. The SA-6 forced aircraft to fly very low where they would encounter the ZSU-23-4 self-propelled anti-aircraft gun. It has been widely deployed, not only with the Warsaw Pact, but with many other countries that have received Soviet aid. Subsequent use of the SA-6 in combat has included the war between Iraq and Iran, the Syrian-Israeli missile crisis in Lebanon during 1981 and the Israeli invasion of Lebanon in 1982. It has been used by both the Polisario Front and Algeria in border skirmishes with Morocco, destroying at least six aircraft (one C-130 Hercules airborne command post, one F-5 fighter bomber, one Puma helicopter and two F-1 Mirages to a Polisario SA-6 unit in October 1981 and one F-1 Mirage to Algerian Air Defence Troops in January 1985), and by both Egypt and Libya during their 1977 seven-day border war. It was used by Libya during the 15 April 1986 bombing attack by the USA and against French



SA-6 'Gainful' missile being launched

aircraft in the battles in northern Chad during 1986 and 1987. It has also been used by Angola against South African aircraft with negative results.

Previously in Army level air defence units, the SA-6 is now found mostly at Divisional level in the anti-aircraft Regiment. Each SA-6 Regiment consists of a Regimental headquarters, a target acquisition battery (with one Thin Skin-B, a Score Board-A IFF radar, one Spoon Rest radar, one Flat Face radar and one Long Track radar) and five SA-6 batteries. Each



ZRK-SD (Kub) SA-6 'Gainful' surface-to-air missile system SPU with three-round launcher traversed to front (not to 1/76th scale) (Steven Zaloga)

battery in peacetime consists of one SSNR Straight Flush radar vehicle, four SA-6 SPU launcher vehicles and four ZIL-131 T2M reload vehicles each with a large hydraulic crane centrally located on the tailboard and three reserve missiles. There are a further two Ural-375 crane trucks and 15 ZIL-131V or ZIL-157V articulated tractors towing double-axle semi-trailers carrying six resupply rounds each in the missile technical battery of the Regiment. On mobilisation for war each battery would receive two further launchers, normally kept in storage. Other users normally have only four launchers per battery.

Only a very limited number of Soviet Army units use the SA-6b SPU.

#### Description

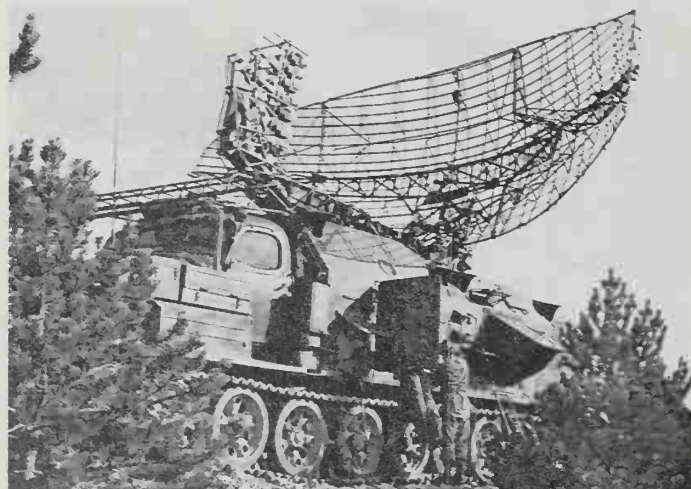
Developed by the Astrovo KB design bureau, the SA-6 is related to the ZSU-23-4 self-propelled air defence system and the ASU-85 self-propelled

anti-tank gun. The SPU (Soviet Industrial Index designation 2P25) is all-welded with the crew compartment at the front, missiles on the turntable immediately behind the crew compartment and the engine at the rear. The driver is seated at the front of the hull on the left side with the vehicle commander to his right. Both have a large windscreen to their front which can be covered by a single-piece hatch cover hinged at the top which opens on the outside. When these hatches are closed, forward observation is via periscopes mounted in the forward part of the crew compartment. On the glacis plate is a splash plate to stop water rushing up the front of the vehicle when fording.

The engine and transmission are at the rear of the hull. The torsion bar suspension system consists of six rubber-tyred road wheels with the drive sprocket at the rear and the idler at the front. There are no track return rollers. Hydraulic shock absorbers are provided for the first and last road wheel stations. The SA-6 vehicle has an air filtration and overpressure NBC system and infra-red night vision equipment fitted as standard but the vehicle has no amphibious capability.

Three SA-6 missiles are carried on a turntable which can be traversed through a full 360° with the missiles elevated on their launchers to a maximum of +85°. When travelling the turntable is normally traversed to the rear and the missiles are horizontal to reduce the overall height of the vehicle.

It is estimated that the SA-6a (NATO designation 'Gainful' Mod 0) missile has a length of 5.7 m, body diameter of 0.335 m, wing span of 1.245 m,

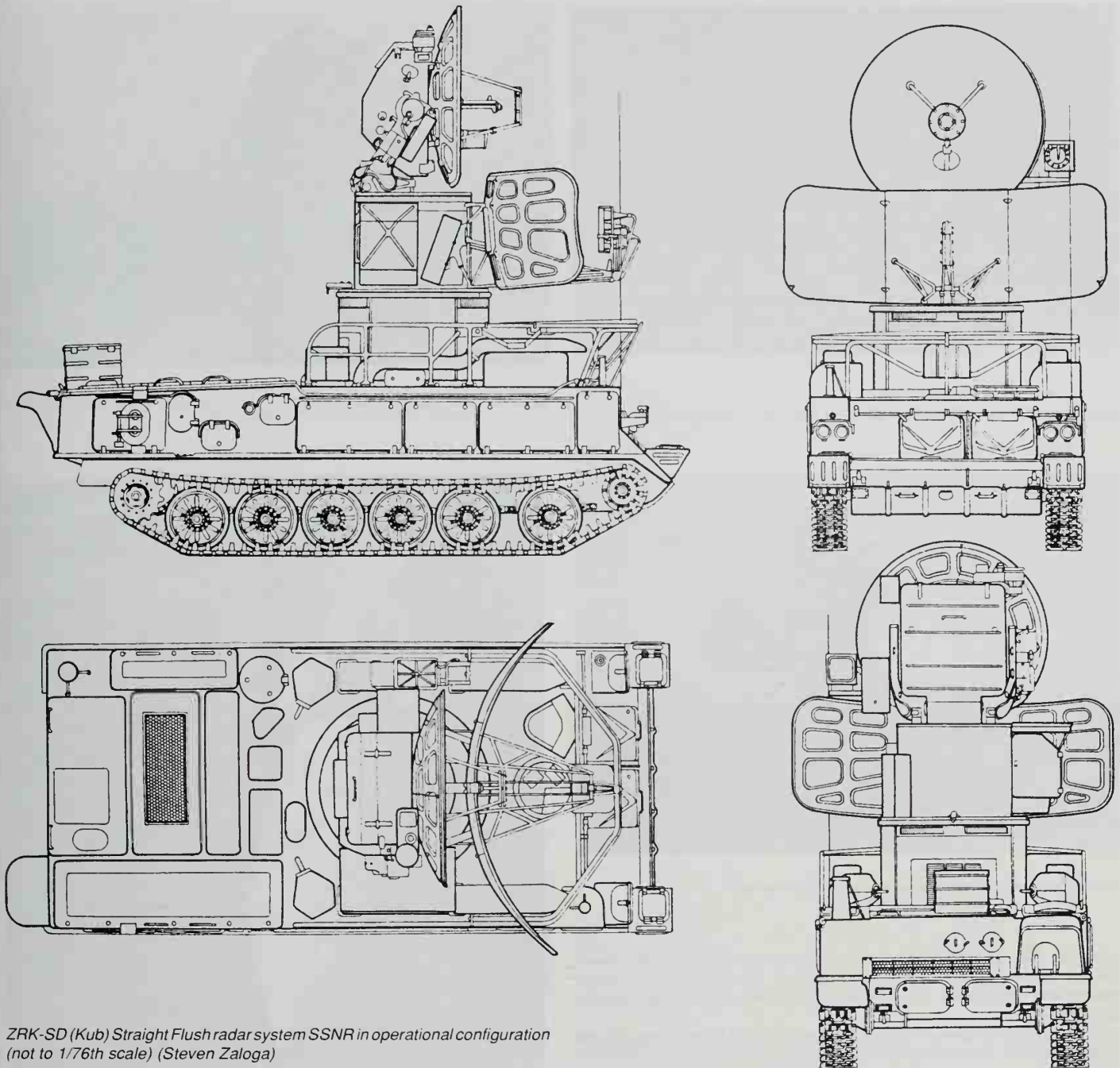


Long Track E-band surveillance radar on AT-T tracked chassis



Czechoslovakian SSNR Straight Flush radar vehicle in travelling configuration





ZRK-SD (Kub) Straight Flush radar system SSNR in operational configuration (not to 1/76th scale) (Steven Zaloga)

tail span of 1.524 m and has a launch weight of 599 kg with a 56 kg HE-fragmentation warhead. The proximity and contact fuzes are armed after some 50 m of flight.

The missile has an integral ram/rocket propulsion system. The latter accelerates the missile for 4.1 seconds after launch to a speed of about Mach 1.5 when the solid-propellant booster rocket nozzle at the rear is jettisoned and the missile is then propelled by a solid-fuel ramjet with a much larger nozzle. It is fed with ram air from the four ducts just in front of the centrebody wings, maximum speed then reaches approximately Mach 2.8. Total sustainer burn time is 22.5 seconds. The missile airframe can stand a maximum turning force of 15 g and a linear acceleration of 20 g. It is capable of 15 g maximum sustainable manoeuvres and is controlled by cruciform centrebody wings with ailerons for roll control. Tail fins carry I-band mid-course command link receiver antennas and G/H-band beacon transmitter antennas. These antennas were not observed on the first version of the SA-6 seen in the 1960s (Soviet Industrial Index designation 3M9, and redesignated 9M9 and 9M9M1 for the latter missile versions in the late 1970s). Terminal homing is of the semi-active radar type.

The basic SA-6a has a maximum effective range of 24 000 m and a minimum effective range of 3000 m, the minimum engagement height is 100 m when using the Straight Flush fire control radar and 80 m when in the optical tracking mode, the maximum effective altitude is about 11 000 m. Reload missiles are carried on modified ZIL-131 (6 × 6) trucks and are loaded manually onto the launcher by a crane carried on the rear of the loader vehicle. Reloading an SPU takes approximately 10 minutes.

Straight Flush has a similar chassis to that of the SA-6 with a range of 55 to 75 km and a 10 000 m altitude capability depending upon conditions and target size, and performs limited search, low altitude detection/acquisition, pulse Doppler IFF interrogation, target tracking and illumination, missile radar command guidance and secondary radar missile tracking functions. The vehicle also carries the fire control computers for the missile battery. Some modified Straight Flush vehicles have been observed with a TV camera of 30 km range to enable the battery to remain in action even if the vehicle's radars are jammed or forced to shut down because of the threat of anti-radiation missiles. Straight Flush can also be linked to the launch vehicles by either a radio data link or a 10 m long cable for direct data input to the launcher's systems. The data link antenna is carried on the right forward hull corner of the SPU.

The upper foldable Straight Flush 28 km range dish antenna is of the conical scanning type and is used for low altitude H-band sector search scans, target tracking and target illumination. The lower parabolic antenna is of the G-band 55 to 75 km range medium altitude target acquisition and early warning radar type, with the lower feed for medium to high altitude coverage and the upper feed for low altitude coverage.

A typical engagement takes place as follows. The surveillance radars acquire potential targets at ranges of up to 275 km. The target height is confirmed by the Thin Skin radar and all the data is sent to the Regimental operations centre either by landline or radio data link. The operations van interprets the radar data and selects the appropriate battery to engage the targets. Data on the selected target is passed to a Regimental signals van



SA-6 'Gainful' low altitude surface-to-air launcher in firing position



Polish Straight Flush radar system in close up



Polish Straight Flush radar system with radars to rear

and then onto the firing battery command and control centre truck. This is usually located near to the battery's Straight Flush engagement radar vehicle and connected to it by a landline. The data is then passed on to the Straight Flush.

In most situations the Straight Flush does not start transmitting until the target has been acquired and allocated by the Regimental headquarters. Radar silence is maintained as long as possible to prevent the location of the battery being compromised to threat ELINT locating systems. The Straight Flush can begin target acquisition at its maximum range of 75 km, and begin tracking and illumination at the 28 km mark. The Straight Flush can only illuminate a single target and control three missiles at any one time so Soviet practice when a target track has been initiated is to normally order the launch of two and sometimes three weapons from one or more SPUs. These are tracked using their G/H-band tail fin tracking beacons to monitor the trajectories.

The Straight Flush fire control computer uses these signals to generate course corrections and each weapon is then guided on an intercept course via control transmission commands sent to the reference antenna located on the lower left tail fin. The missile's terminal attack phase is flown in a semi-active homing mode with the seeker homing in on the reflected energy from the continuous wave illumination radar. The course flown in both phases is of the lead pursuit type. At the intercept point the warhead is detonated either by direct contact or the Doppler radar proximity fuzing system.

With radars up, reaction time from a dormant condition through the target acquisition, IFF interrogation and lock-on phases to missile launch is about three minutes. If the radar vehicle is already active then the time taken for the sequence is reduced to between 15 to 30 seconds. A battery is able to become mobile and relocate to an alternate firing position in approximately 15 minutes from systems being shutdown.

Egyptian SA-6 systems have had their Soviet auxiliary power unit turbines replaced by Garrett Turbine Engine Company GTP-30-150 APU that supply up to 75 kW for system operations on the Straight Flush SSNR (25 kW required) and SPU (35 kW required). The missiles themselves have also



SA-6 'Gainful' SAM in its transport/resupply container

been renovated with Chinese and US assistance. The former country has begun reverse-engineered manufacture of the missile for the export market.

#### Variants

In 1977 the SA-6b (NATO designation 'Gainful' Mod 1), a derivative of the 9M9M1 missile, entered service mounted on an SPU which was based on the GM-539 medium-tracked transporter and subsequently used for the SA-11 system. The SPU carried three SA-6b missiles and an associated Fire Dome H/I-band missile guidance illuminator radar fitted on the front end of the launcher assembly. The SA-6b was initially deployed on the basis of one SPU per SA-6a battery, as an interim system until the complete SA-11 'Gadfly' system was fielded. The Syrians were also given the system following the débâcle in the Bekaa Valley during the 1982 Peace for Galilee War with Israel.





SA-6 'Gainful' SAM system in travelling configuration with launcher traversed to front

#### SPECIFICATIONS

CREW	3
COMBAT WEIGHT	14 000 kg
POWER-TO-WEIGHT RATIO	17.14 hp/t
GROUND PRESSURE	0.48 kg/cm <sup>2</sup>
LENGTH OVERALL	
including missiles	7.389 m
hull	6.79 m
WIDTH	3.18 m
HEIGHT	
including missiles	3.45 m
hull top	1.8 m
GROUND CLEARANCE	0.4 m
TRACK	2.67 m
TRACK WIDTH	360 mm
LENGTH OF TRACK ON GROUND	3.8 m
MAX ROAD SPEED	44 km/h
FUEL CAPACITY	250 l
MAX RANGE	260 km
FUEL CONSUMPTION	0.96 l/km
FORDING	1.1 m
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	1 m
TRENCH	2.5 m
ENGINE	model V-6R, 6-cylinder, in-line, water-cooled diesel developing 240 hp at 1800 rpm
TRANSMISSION	manual with 5 forward and 1 reverse gears



Iraq has converted a number of Soviet supplied SA-6 SAMs into the ground/ground role and called them the Kaser

STEERING	clutch and brake
SUSPENSION	torsion bar
ELECTRICAL SYSTEM	24 V
BATTERIES	2 × 12 V, 100 Ah (for vehicle)
ARMAMENT	3 SA-6 missiles
SMOKE-LAYING EQUIPMENT	none
ARMOUR	9.4 mm max

Status: Production complete. In service with the following countries:

Country	Quantity	User
Algeria	40	air force
Angola	72	Air Defence Force
Bulgaria	40	army
Cuba	12	army
Czechoslovakia	120	army
Egypt	60	Air Defence Command
Hungary	44	army
India	100	army
Iraq	n/av	army
Libya	160	army
Poland	100	army
Polasario Front	4+	guerrilla force
Romania	40	army
Syria	108	army
	108	Air Defence Command
Tanzania	12	army
USSR	850	army
Vietnam	80	army
Yemen	40	army
Yugoslavia	80	army

Manufacturer: Soviet state factories, Chinese state factories (missile only).

## SA-8 'Gecko' Low Altitude Surface-to-air Missile System

### Development

The SA-8 'Gecko' (its US/NATO designations) all-weather low altitude surface-to-air missile system entered service in 1974 and was first seen in public during a parade in Moscow in November 1975. The system, known as ZRK-SD *Romb* (Russian for Diamond) in the Soviet Army, has been designed to fill the gap between the SA-7/SA-9 and the SA-6 and was followed by the development of the modified SA-N-4 point defence system used by the Soviet Navy. The Soviet designation is OSA-AKM (Osa is Russian for Wasp).

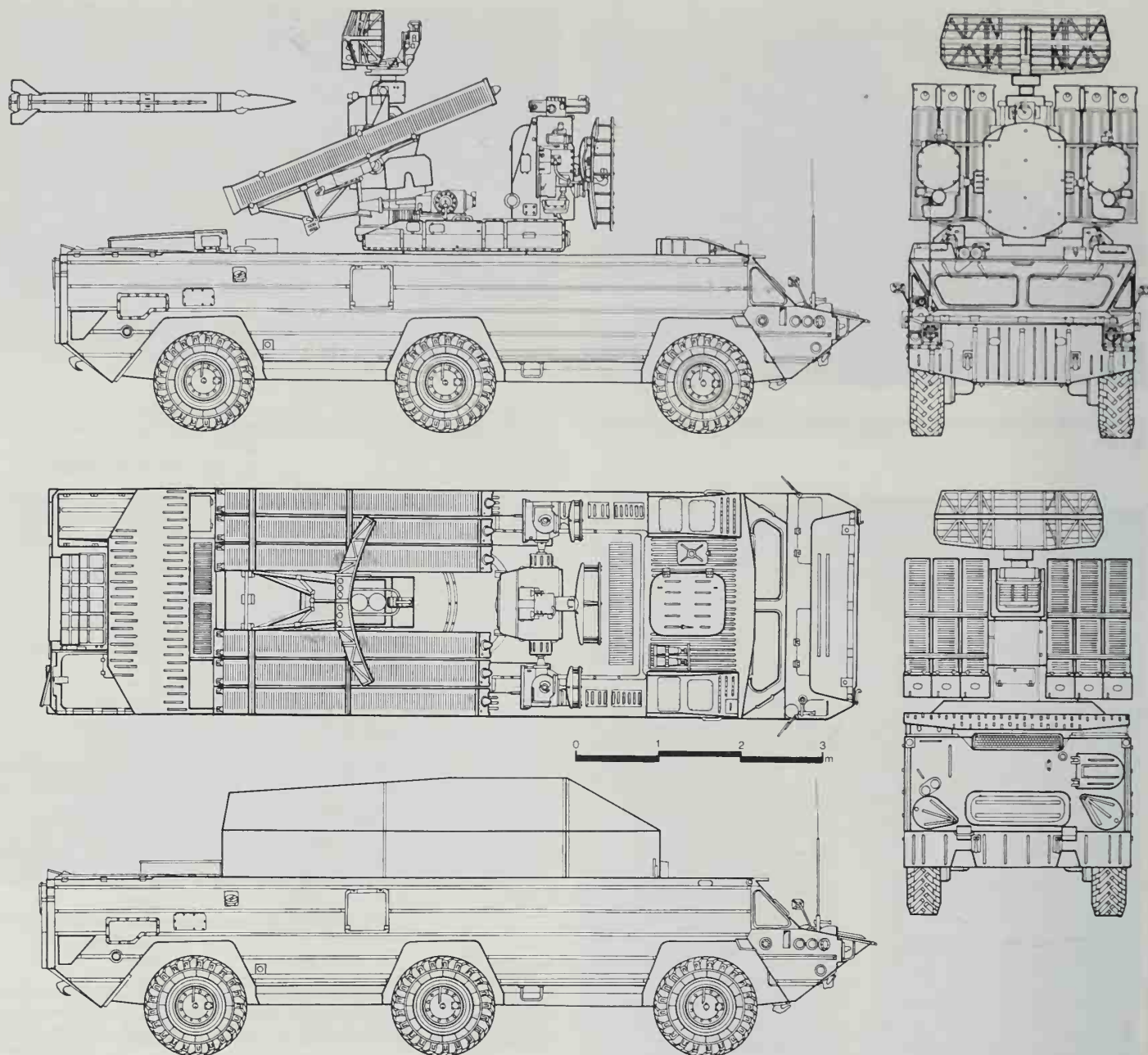
The main design and development work on the SA-8 system was carried out by the 'Antey' Scientific Industrial Organisation. It began at approximately the same time as the design of the defunct American Mauler system (that is, 1959-60). The basic concept was to incorporate all the elements of an entire missile operation engagement cycle onto one vehicle that is, to find, fix, track, engage and guide the weapon to the target. To indicate this is a complete and integral SAM system the Soviets have called it a ZRK (*Zenitnyi Raketnyi Kompleks*) system.

The SA-8 'Gecko' is issued on the scale of 20 fire units per Soviet Divisional anti-aircraft regiment in place of the S-60 57 mm towed anti-aircraft gun. The organisation of an SA-8 regiment is a regimental headquarters, a target acquisition and early warning battery with one Long



Iraqi TQM resupply vehicle with forward part of roof covering folded to rear to show hydraulic crane that is used to lift three new missiles in their launch containers

Track, one Flat Face and a Thin Skin-B radar, a missile support battery, a transport company, a maintenance company and five SA-8 batteries. Each battery in peacetime has four SA-8 SPU launcher vehicles and two TQM



ZRK-SD Romb (SA-8b 'Gecko' Mod 1) and its supporting TBM resupply vehicle (not to 1/76th scale) (Steven Zaloga)

reload vehicles. The TZMs are supported by 24 ZIL-131 (6×6) cargo trucks used as missile transporters by the Regimental transport company. On mobilisation a further two launchers are added to each battery. It has also replaced the SA-6 system in some units because of its greater mobility. It is airtransportable in the An-22 and IL-76 transport aircraft.

First recorded combat use was in the Bekaa Valley region of Lebanon, in late July 1982, when Israeli aircraft destroyed three of these systems belonging to the Syrians, a fourth SPU subsequently shot down an Israeli RF-4E Phantom. Angola subsequently used it during the December 1983 South African cross-border raid code named Askari. It was also used by Libya during the 15 April 1986 American bombing attack without success.

During the 1987/88 battles in Angola against the South African Air Force the FAPLA SAM units equipped with the SA-8 destroyed two Seeker RPVs and an Aermacchi/Aeritalia AM-3C Bosbok light piston-engined artillery spotting and visual observation post aircraft.

Considerable numbers of SA-8 launchers and associated vehicles were destroyed in ground combat and by airstrikes. In addition a complete SA-8 launcher vehicle with associated BTR-60PU-12 fire control and BTR-60 logistic vehicles (the latter with reload rounds aboard) were captured intact by a South African ground unit, during the October 1987 Lomba River battle with the Angolan 47th Brigade.

During the 1991 Gulf War against the Coalition Forces Iraqi SA-8 units were credited by the Soviets as being one of the most effective elements of the Iraqi Air Defence Forces, together with the ZSU-23-4 'Shilka', against

the Tomahawk cruise missile. A number of Tomahawk missile losses are attributed by the Soviets to hits from SA-8 weapons.

The Soviet Naval Infantry Division attached to the Pacific Fleet has a regiment of SA-8b systems.

#### Description

The Soviet Industrial Index numbers for the various system components are:

- (a) 9M33BM3 - launch vehicle (latest version)
- (b) 9M33 - missile (latest version is 9M33M3)
- (c) 9T217BM2 - reload vehicle
- (d) 9V210M3 - technical maintenance vehicle
- (e) 9F372M3 - vehicle with SPTA set
- (f) 9V914 - vehicle with adjusting equipment
- (g) 9F16M2 - ground equipment set
- (h) 9V242-1 - automatic control and test station.

The SA-8 vehicle is a six-wheeled design designated BAZ-5937. It is based on a number of earlier six-wheeled all-terrain vehicles developed by V A Grachev's design team at the Likhachev Automobile Plant (ZIL) in Moscow. The driver's compartment at the front of the vehicle has accommodation for two, the driver and commander, with access to it via a hatch in the roof. There are no other entrance/exit hatches apparent on the vehicle. The engine is at the very rear. The vehicle is thought to have torsion bar suspension with steering on the front and rear axles and a central tyre-pressure regulation system. Blast shields can be folded down





SA-8a 'Gecko' in travelling configuration with surveillance radar lowered to rear (US Army)

over the windscreens to prevent damage when the missiles are launched. The vehicle is fully amphibious, being propelled in the water by two water jets at the rear of the hull. Before entering the water, a trim vane which is folded back onto the glacis plate when not in use is erected at the front of the hull. The vehicle is fitted with an air filtration and overpressure NBC system together with IR systems for the commander and driver. Four command-guided missiles are carried ready to launch, two either side.

The main fire control radar is at the rear of a one-man gunner-radar operator position and folds back 90° to reduce the overall height of the vehicle for air transport and during high speed road travel. It is known that the radar operates in the H-band with a 360° traverse and has a maximum range of 35 km. The complete conical-scan radar installation of the 'Gecko' has been assigned the NATO code name Land Role.

In front of the radar is the guidance group comprising a central monopulse target tracking radar with truncated sides, which operates in the J-band and has a range of 25 km, two monopulse missile guidance radar up-link transmitters, one either side of the tracking radar, which have truncated sides and limited traverse and operate in the J-band; two command-link

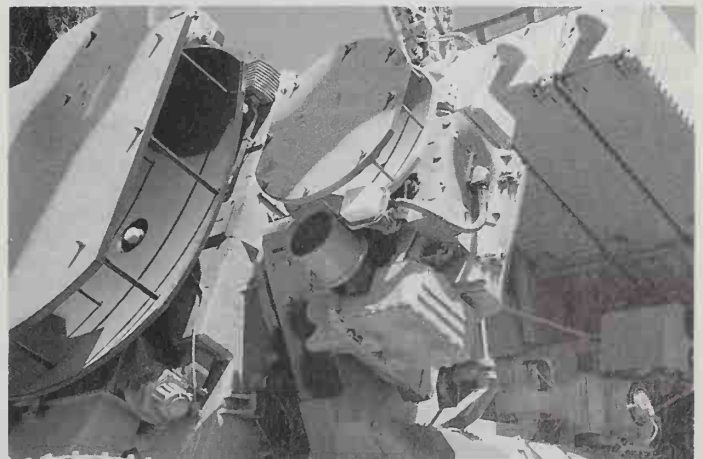
horns for missile gathering, one either side and below the missile guidance radars, which operate in the I-band and two rectangular devices which are believed to assist in tracking in an ECM environment to the left and right of the missile guidance radars. Mounted on top of each missile guidance radar is an LLLTV/optical assist system for target tracking in low visibility and heavy ECM. Mounted on the top of the tracking radar is what is thought to be a feed and below the tracking radar is a periscope, the exact role of which is uncertain. Land Role is also known to have a short-range target acquisition capability.

It is known that the two missile guidance radars operate on different frequencies, each controlling one missile in flight, which would enable the system to engage a single target with a staggered two-missile salvo operating on different frequencies to avoid guidance problems and degrade the target's ECM capabilities.

The SA-8a ('Gecko' Mod 0) high acceleration missile (given the Soviet Factory Index number 9M33) is powered by a single-stage rocket motor burning solid propellant, has a launch weight of about 130 kg, is 3.15 m long, 0.21 m in diameter and has a span of 0.64 m. Maximum speed is Mach 2.4, minimum altitude is 25 m, maximum effective altitude 5000 m. The minimum range is 1500 m and the maximum range 12 000 m. Against an F-4 Phantom target the warhead's lethal radius at low altitude is 5 m and is fitted with proximity and contact fuzes. In 1980 a newer missile, the SA-8b or 'Gecko' Mod 1, was introduced into service. Contained in a rectangular launch box it has improved guidance and speed characteristics to give an increased maximum range of 15 000 m. The warhead weight of both missiles is 19 kg. The booster section of the dual thrust solid rocket has a



SA-8b 'Gecko' in travelling configuration with surveillance antenna retracted



Close up of SA-8b radar system with target tracking radar on left and one of the two monopulse missile guidance radar up-link transmitters on the right (Christopher F Foss)



*Iraqi SA-8b 'Gecko' system from rear with surveillance system erected (Christopher F Foss)*

two second firing period whilst the sustainer section has a 15 second duration. The reloading time is five minutes. Each battery also has two missile transloaders based on the same chassis with a long coffin-like blunt pointed tarp roofed structure covering the cargo space and crane. When operating, the blunt point area is raised and the tarped structure is slid to the rear. A total of 18 reloads in boxed sets of three are transferred to the SPUs by the hydraulic crane mounted centrally behind the vehicle cab. In the Regiments Maintenance battery there is a single radar collimation vehicle using the same chassis. This has a collimation antenna which lies on both sides of the vehicle and overhangs the rear during transit. In operation it is raised and mounted on each side of the hull directly behind the cab.

Combat deployment time is four minutes with system reaction 26 seconds.

#### Variants

There are at least three major families of SA-8 launch vehicles. The first has a very blunt nose, and may be a pre-series prototype. The standard production type for the SA-8a has a sharper nose, and there appear to be sub-variants of this vehicle with minor changes in the detail of hull fittings. The SA-8b vehicle is basically similar to the SA-8a vehicle mentioned above aside from the launcher details to accommodate six missile canisters. There are also indications that a distinctly different SA-8b launcher may exist, with a reconfigured rear end.

In 1991 SA-8b TELs were seen with an additional small sized radar antenna fitted above the surveillance radar. It is possible that the antenna may be associated with a new IFF system.



*TZM resupply vehicle in travelling configuration with battery BTR-60PU-12 Air Defence Command Vehicle behind. The TZM is provided with a hydraulic crane to resupply the SA-8 'Gecko' system in the field*

#### SPECIFICATIONS (SA-8b)

CREW	5
COMBAT WEIGHT	17 500 kg
LENGTH	9.14 m
WIDTH	2.8 m
HEIGHT	
surveillance radar lowered to hull top	4.2 m
GROUND CLEARANCE	1.845 m
WHEELBASE	0.4 m
MAX SPEED	3.075 m + 2.788 m
road	60 km/h
water	8 km/h
CRUISING RANGE (road)	500 km
FUEL CAPACITY	350 l
VERTICAL OBSTACLE	0.5 m
TRENCH	1.2 m
FORDING	amphibious
ENGINES	D20B-200 diesel developing 200 hp at 2000 rpm and one gas turbine which is used as an auxiliary power unit
ARMOUR	none
UNIT OF FIRE	6 x SA-8 missiles

**Status:** In production. In service with the following countries:

Country	Quantity	User
Algeria	20	army
Angola	72	army
Czechoslovakia	40	army
India	48	army
Iraq	n/av	army
Jordan	23	air force
Libya	40	army
	50	Air Defence Command
Poland	60	army
Syria	50	army
USSR	1000+	army
Yugoslavia	20	army

**Manufacturer:** 'Antey' Scientific Industrial Organisation.

Enquiries to: V/O 'AVIAEXPORT' 48 Ivan Franko Street, 121351 Moscow, Russian Republic.

Telephone: 417-00-55

Cable: Moscow, 351, Aviaexport

Telex: 411929

## SA-9 'Gaskin' Low Altitude Surface-to-air Missile System

#### Development

Apparently developed in parallel with the ZSU-23-4, the first SA-9 launchers were produced in 1966 with the system attaining operational status in 1968,

the SA-9 'Gaskin' (US/NATO designations) low altitude clear-weather surface-to-air missile system's first recorded combat use was in May 1981 when a Libyan SA-9 battery engaged Israeli aircraft flying over Lebanon; no hits were made and the battery was destroyed in a retaliatory airstrike. Israel subsequently captured a single SA-9 launcher in Lebanon for which the search radar coverage was provided by a J-band Gun Dish radar system mounted on a ZIL-157 truck chassis. Around 14 SA-9 launchers





SA-9 'Gaskin' SAM system based on BRDM-2 (4 × 4) amphibious chassis with four missiles ready to launch

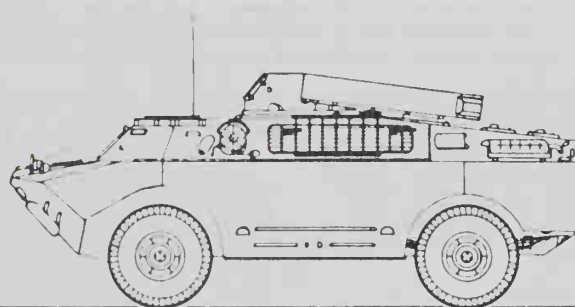
were also destroyed by the Israelis in their destruction of the Bekaa Valley Syrian missile belt during the 1982 Lebanon invasion. In December 1983 a US Navy A-6E Intruder was shot down by a Syrian SA-9 missile during an attack by the US Fleet. In the same raid an A-7E Corsair was lost, possibly to a combination of SA-7/SA-9 missiles. Iraq used SA-9s against Iran in the Gulf War. One SA-9 vehicle was captured together with missiles by South Africa following operation Askari in Angola during 1983 after several missiles had been fired at its aircraft on bombing and reconnaissance missions. A further 15 launchers were captured in later operations.

The SA-9 'Gaskin' is issued to the anti-aircraft batteries of Soviet motorised and tank regiments on the basis of four systems per battery to give a total of 16 per division. Replacement by the SA-13 'Gopher' system is well underway. Recently higher readiness Tank and Motorised Rifle Divisions have begun to field enlarged Regimental level air defence battalions of six ZSU-23-4 and six SA-13 'Gopher' vehicles. It is possible that the same structure is being adopted for the lower readiness Divisions still equipped with SA-9 vehicles. Some of the forward deployed Category 1 Divisions have had their air defence battalions of SA-13/ZSU-23-4 vehicles replaced by battalions fielding six 2S6 and six BMP-2, the latter apparently being used to transport regimental level SA-14/SA-16 manportable SAM teams. The surveillance unit equipped with a Dog Ear radar vehicle remains the same.

The SA-9 is also organic to the Soviet Naval Infantry Regimental and Brigade level air defence batteries, with four launchers and four ZSU-23-4 assigned. These systems can be used to supplement the air defences of amphibious warfare vessels by being deployed on deck. The Soviet Naval Infantry has replaced the SA-9 on a one-for-one basis with the SA-13.

#### Description

The system consists of a BRDM-2 transporter erector launcher (TEL) with the normal turret and chain-driven belly wheels removed and replaced by one with four ready to launch SA-9 container-launcher boxes. These are normally lowered to the horizontal when travelling to reduce the overall height of the vehicle. The original version of the Strela-1 was known as the 9M31 (US designation SA-9a, NATO code name 'Gaskin' Mod 0) and used an uncooled first-generation lead sulphide (PbS) infra-red (IR) seeker operating in the 1-3  $\mu$ m waveband region. This was supplemented by the



SA-9 'Gaskin' SAM system based on BRDM-2 chassis, with launching arms and missiles in travelling position

9M31M variant (US designation SA-9b, NATO code name 'Gaskin' Mod 1) which has an improved PbS seeker operating in the 1-5  $\mu$ m waveband region to provide greater target sensitivity and lock on ability. The 30 kg Mach 1.5 missile is 1.8 m long, 0.12 m in diameter and has a wing span of 0.375 m. The minimum range of the 9M31 is 800 m and the maximum range 6500 m within altitude limits of 15 to 5200 m. The minimum range of the 9M31M is 560 m and the maximum range 8000 m (increasing to a possible 11 000 m when used in a tail-chase engagement) within altitude limits of 10 to 6100 m. When engaging a head-on target the system has a considerably reduced range. The SA-9 is fitted with an HE-fragmentation warhead and proximity fuze with a lethal radius of 5 m and damage radius of 7.6 m. One SA-9 TEL (known to the US Army as the SA-9 Mod A, BRDM-2A1 or SA-9A TEL) in each battery has been fitted with Flat Box A passive radar detection antenna, one either side of the hull above the front wheel housings, one under the left launch canisters pointing forward and one mounted on a small frame above the rear engine deck plate pointing rearwards to give 360° coverage. The TEL with no Flat Box A system is known to the US Army as the SA-9 Mod B, BRDM-2A2 or SA-9B. The vehicle crew of three consists of the commander, driver and gunner and there is an IR system for the first two to use at night. An air-filtration and overpressure NBC system is fitted as standard.

In the Soviet Army the BTR-60PU-12 command vehicle of the SA-9 unit is usually alerted by the Divisional Air Defence Regiment's command post as to a potential target's azimuth, range and altitude. This information is assessed with additional data from the unit's own visual observer network and any microwave transmissions picked up by the SA-9A Flat Box TEL. The commander then instructs the unit as to which target should be engaged by which vehicle and orders the engagement(s) to commence.

The designated TEL moves to its predetermined launch site using its onboard basic Inertial Navigation System (INS) located near to the vehicle commander's station. All the commander has to do to use the system is insert the co-ordinates of the SPU's 'hide' position, the co-ordinates of the preselected launch site and then read off the bearing and distance information calculated by the INS.

Once there the gunner manually directs the turret to the desired azimuth bearing and elevates the launcher assembly. He then selects the missile(s) to be used and acquires the target through an optical sight mounted behind a plexiglass window at the base of the turret. Once the target is acquired the gunner presses the launch button to its initial stop position. This opens the designated missile's canister front door and uncages the IR seeker. When lock-on by the IR seeker is achieved an aural signal sounds in the turret and the gunner depresses the launch button to its second and final stop position. This fires the missile's dual-thrust solid propellant rocket motor.



SA-9 'Gaskin' low altitude SAM system showing Flat Box A passive radar detectors either side of hull front



SA-9 'Gaskin' SAM system in travelling configuration with missiles folded down

In combat the missiles are usually sequentially fired (two per target) to increase the kill probability with a time between rounds of about five seconds. Reloading is performed manually and takes about five minutes to accomplish.

The SA-9 is known as ZRK-BD Strela-1 in the Soviet Army. Strela-2 is the shoulder-launched 9M32/SA-7a, Strela-2M the 9M32M/SA-7b and Strela-3 is the SA-14 'Gremlin'.

#### Variants

The South African firm Kentron has produced an upgrade package for the Strela-1 to allow it to fire the SA-13 missile (qv entry this section).

#### SPECIFICATIONS

CREW	3
CONFIGURATION	4 × 4
COMBAT WEIGHT	7000 kg
LENGTH	5.8 m
WIDTH	2.4 m
HEIGHT (travelling)	2.3 m
GROUND CLEARANCE	0.43 m
TRACK	1.84 m
WHEELBASE	3.1 m
MAX SPEED	
road	100 km/h
water	10 km/h
ROAD RANGE	750 km
FUEL CAPACITY	290 l
FORDING	amphibious
GRADIENT	60%
VERTICAL OBSTACLE	0.4 m
TRENCH	1.2 m
ENGINE	GAZ 41 V-8 water-cooled petrol developing 140 hp at 3400 rpm
ARMAMENT	4 × SA-9 missiles
TRAVERSE	360°
TRACKING RATE	15-20°/s

ELEVATION	+20 to +80°
AMMUNITION	4 + 2 SA-9s
ARMOUR	5-14 mm

**Status:** Production complete. In service with the following countries:

Country	Quantity	User
Algeria	40+	army
Angola	20+	army
Benin	4	army
Bulgaria	50	army
Cuba	60	army
Czechoslovakia	80+	army
Egypt	20	army
Hungary	44	army
India	200	army
Iraq	n/av	army
Libya	60	army
Mauritania	4	army
Mozambique	32	army
Nicaragua	8-12	army
PLO	few	guerrilla force
Poland	200+	army
Polasario Front	4+	guerrilla force
Romania	40+	army
Syria	40+	army
Tanzania	20	army
USSR	n/app	army, naval infantry
Vietnam	450+	army
Yemen	20+	army
Yugoslavia	100+	army (known as S-2M)

**Note:** They are also used by Israel, South Africa and the USA for training purposes

**Manufacturer:** Soviet state factories.

## SA-10 'Grumble' Low to High Altitude Surface-to-air Missile System

#### Development

The US/NATO designation SA-10a 'Grumble' Mod 0 (Soviet designation S-300) missile system was developed in the 1970s as a direct response to the American cruise missile concept. The main design and development work was carried out by the 'Almaz' Scientific Industrial Corporation based in Moscow. The all-weather SA-10 system is able to engage several targets at once and combat intensive raids at all altitude levels from very low up to high level. The SA-10 has also been successfully tested against short-range tactical ballistic missiles and has similar capabilities in this role to those demonstrated by the American MIM-104 Patriot PAC-2 system.

The SA-10a static system entered operational service in 1980 and by 1991 over 200 complexes had been deployed throughout the Soviet Union as replacements for the elderly SA-1 'Guild' (R-113) and SA-2 'Guideline' (S-75) weapons. In 1989 it was revealed that Bulgaria had taken delivery of two SA-10a 'Grumble' complexes to replace two battalions of older weapons (thought to be SA-2 'Guidelines').

In the mid-1980s design work was completed on a mobile version of the system, known by the US/NATO designation SA-10b 'Grumble' Mod 1 (Soviet designation S-300PMU). In this version the weapon is mounted, carried and vertically launched from a dedicated four-round capacity

transporter-erector launcher vehicle based on the MAZ-7910 (8 × 8) truck chassis. The combined engagement radar and control station is mounted on the same chassis.

In 1991 it was revealed that Czechoslovakia was operating several SA-10b batteries.

#### Description

#### SA-10a system

The SA-10a site (complex) is believed to be occupied by a missile battery which deploys a battery command post and engagement control centre, a large 3D continuous wave pulse Doppler target acquisition radar (NATO code name 'Clam Shell'), an I-band multi-function phased-array trailer-mounted engagement radar (NATO code named 'Flap Lid A') with digital beam steering in hardened sites, and up to 12 semi-trailer erector-launchers which mount four tubular missile container-launchers. The towing unit for the semi-trailer erector-launcher is the KrAZ-260V (6 × 6) tractor truck. The



SA-10b 'Grumble' resupply vehicle in travelling configuration



SA-10b 'Grumble' transporter erector launcher vehicle deployed in the firing position with missiles elevated into vertical position





SA-10b 'Grumble' missile resupply vehicle from rear

launchers are usually positioned on concrete pads with the trailers being levelled by the use of four hydraulic jacks.

An SA-10a Regiment probably comprises three such batteries and deploys a 4 m high F-band long-range, 3D surveillance and tracking radar (NATO code name 'Big Bird') at the Regimental command post for initial target detection.

### SA-10b system

The SA-10b mobile missile battery comprises the combined 'Flap Lid B' engagement radar and engagement control/command post station mounted on a MAZ-7910 chassis, up to 12 SPU (*Samokhodnaya Puskovaya Ustanovka*: mobile launcher unit), a trailer-mounted 3D 350° scanning target designation radar (Soviet designation 36D6, NATO code name Clam Shell) and a maintenance section. An SA-10b Regiment probably consists of three such batteries together with an additional radar section and a number of TZM (*Transportno-Zaryahayuschaya Mashina*: transport-loader vehicles) MAZ-7910 transloaders for resupply purposes.

The MAZ-7910 is fitted with a central tyre pressure regulation system that allows the driver to adjust the tyre pressure to suit the type of terrain being crossed with steering being power assisted on the two front axles.

The vehicle is powered by a D12A-525 V-12 water-cooled diesel engine developing 525 hp at 2100 rpm, which gives the vehicle a potential top road speed of 60 km/h.

The SPU version carries a total of four sealed container-launcher cylinders, each of which is used for the storage, transport and launching of a missile. When travelling the launcher system is carried in the horizontal position but at the launch site is elevated to an angle of 90°. The missile was designed to have this vertical launch trajectory so it has the quickest available reaction time capability to counter targets approaching from any azimuth. Between the vehicle cab and the missile launcher system is a raised superstructure with chamfered edges that contains the ancillary generator, test equipment and launcher fire control systems.

The combined 'Flap Lid B' radar/engagement control vehicle has the 2.75 m<sup>2</sup> planar array antenna mounted to the front on a box-like antenna mount and support systems container. When travelling the array is carried horizontally but when deployed it is raised above the container to an angle of approximately 60° in a similar manner to the engagement control radar used in the American Patriot system.

The radar operators and the battery command staff are seated to the rear of the radar cabin in a second fully enclosed cabin, which acts as the engagement control station and contains the operator's consoles, system computers and built-in system functional test equipment.

Missile guidance is of the Track-Via-Missile (TVM) type with the 'Flap Lid' guidance radar capable of engaging up to six targets simultaneously, with two missiles assigned per target to ensure a high kill probability. Maximum target velocity is stated to be 4200 km/h with the battery capable of firing three missiles per second.

The battery takes only five minutes to deploy once it comes to the halt as the vehicles have an electronic inter-vehicle communications and data transmission link that uses elevatable pole-type devices and does not require any interconnecting vehicle cables.



SA-10b 'Grumble' combined engagement radar and control system with radar elevated (left) and SA-10b 'Grumble' transporter erector launcher vehicle in firing position on right

Each of the MAZ-7910 derivative vehicles also has a set of four hydraulic jacks positioned either side between the first/second and third/fourth road wheels which are lowered to the ground to provide a more stable and level environment. Time out of battery for the system is again around five minutes.

If the battery is employed in rugged terrain or forest then the engagement radar system and box-like superstructure can be mounted on a special trailer-mounted extendable 24.4 m high tower to improve radar coverage. If this type of radar is used in its extended state then the low level engagement range of the SA-10 system is said to increase to 43 200 m from the original 32 000 m.

### SA-10 missile

The vertically launched SA-10 missile is a single stage weapon powered by an air-fired solid propellant rocket motor. Missile length is approximately 7 m, diameter 0.45 m and maximum wing span 1 m. Launch weight is estimated to be in the order of 1500 kg. The warhead is normally a 100 kg plus HE-fragmentation type with proximity fuzing although a low yield tactical nuclear type is believed to be a possible option. Missile engagement altitude limits extend from 25 m upwards to about 30 000 m. Maximum engagement range is stated by the Soviets to be 90 000 m, although in practice it is probably greater than this (for example, American reports indicate 100 km or greater).

When in its sealed container-launcher cylinder the missile is considered to be a round of ammunition and is said not to require any check-ups or adjustments for a period of 10 years.

### Variants

The Soviet Navy uses a navalised version of the SA-10 system designated SA-N-6 by NATO. This was trialled on the Kara class ASW cruiser *Azov* and operationally deployed on the Kirov class battlecruisers and the Slava class missile cruisers.

### SPECIFICATIONS (provisional SA-10b SPU)

CREW	4
CHASSIS	MAZ-7910 (8 × 8)
COMBAT WEIGHT	20 000 kg
LENGTH	9.4 m
WIDTH	3.1 m
HEIGHT	3.7 m
MAX SPEED (road)	60 km/h
MAX RANGE (road)	650 km
ENGINE	D12A-525 V-12 water-cooled diesel developing 525 hp at 2100 rpm
ARMOUR	none
UNIT OF FIRE	4 × SA-10 missiles

**Status:** Production. In service with Bulgaria (SA-10a), Czechoslovakia (SA-10b) and the Soviet Union (SA-10a and SA-10b).

**Manufacturer:** 'Almaz' Scientific Industrial Corporation, 80 Leningradsky pr, 125178 Moscow, Russian Republic.  
Telephone: (095) 158-96-04  
Fax: (095) 158-56-71

Enquiries to: V/O 'AVIAEXPORT' 48 Ivan Franko Street, 121351 Moscow, Russian Republic.  
Telephone: 417-00-55  
Cable: Moscow, 351, Aviaexport  
Telex: 411299

## SA-11 'Gadfly' Low to Medium Altitude Surface-to-air Missile System

### Development/Description

The SA-11 'Gadfly' (US/NATO designations) mobile missile system was developed in the early 1970s and entered service in 1979 to replace the SA-4 'Ganef' in Army level Brigades. The system provides defence against high-performance aircraft and cruise missiles. The launcher vehicle, which is based on the GM-569 tracked chassis, carries four ready to fire missiles on a turntable that can be traversed a full 360° and H/I-band Fire Dome monopulse guidance and tracking radar. The associated tracked SSNR vehicle uses the same chassis and carries the early warning and acquisition radars (NATO code name Tube Arm) and provides the target's height, bearing and range data. Once a target is identified then it is turned over to an SPU via a data link for tracking and attack. The Mach 3 semi-active homing missile closely resembles the US Navy's Standard MR1 RIM-66 weapon with a maximum slant range of 28 km and a minimum range of 3 km. It is capable of engaging targets between the altitude limits of 30 and 14 000 m and can sustain 23 g manoeuvres. The missile length is 5.6 m, diameter is 0.4 m and the wing span is 1.2 m. Launch weight is 650 kg with a 90 kg HE warhead. Propulsion is by a solid fuel rocket motor.

An SA-11 regiment comprises five batteries each with four SPU's and one SSNR radar vehicle supported by missile transloaders on the same

GM-569 chassis, and command vehicles. There are also two long-range early warning radars in the Regiment's Target Acquisition Battery mounted on the same unarmoured chassis, with a large shelter body, to replace the Long Track vehicles. The radar is carried in a folded position and when erected extends in height for better low altitude observation. The SA-11 can also be integrated into the SA-6 air defence network using that system's Straight Flush radar vehicle to provide all the necessary target acquisition data in place of its own radar vehicle.

### SPECIFICATIONS (Provisional)

CREW	4
COMBAT WEIGHT	30 000 kg
LENGTH	8.75 m
WIDTH	3.34 m
HEIGHT	4.7 m
MAX SPEED	65 km/h
MAX ROAD RANGE	300 km
ARMOUR	9 mm (max)

**Status:** In production. In service with the Soviet Army, also deployed with India (Army), Syria (Army, about 20 launchers), Poland (Army, about 20 launchers) and Yugoslavia (Army manned Protiv- Vazdušna Obrana—literally Protective Air Defence units).

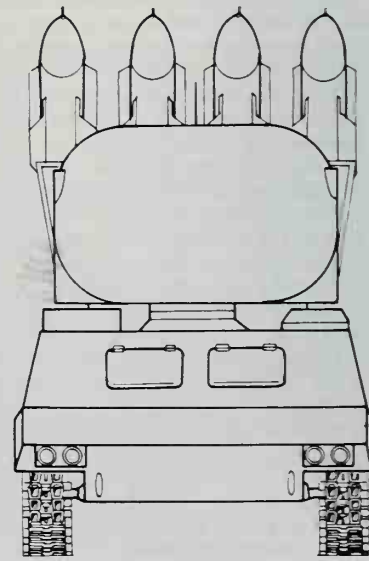
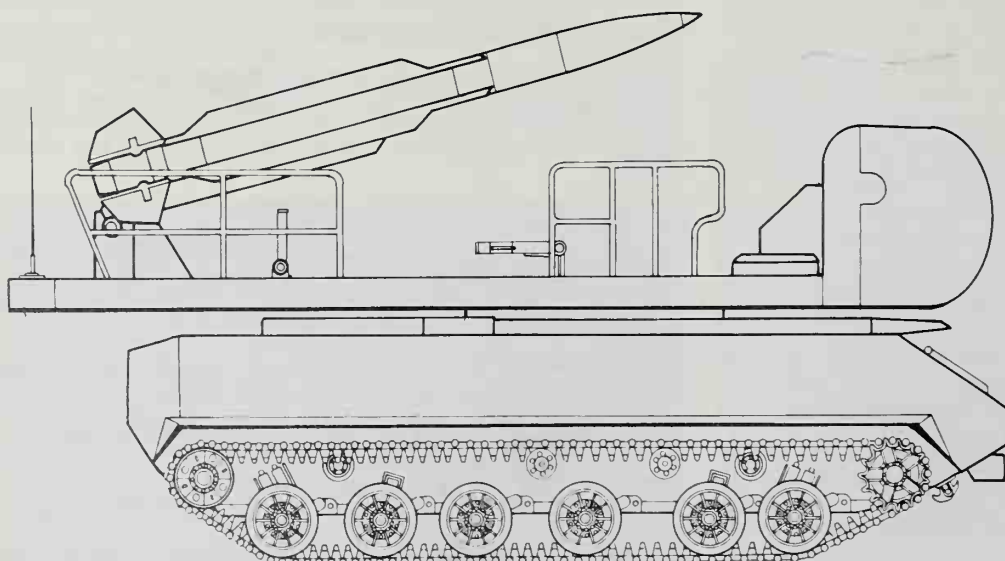
**Manufacturer:** Soviet state factories.



A radar used with SA-11, which may have the US/NATO designation of 'Snow Drift'. This is mounted on a similar tracked chassis to the SA-11 launcher and provides data on the target's height, bearing and range (Jane's Intelligence Review)

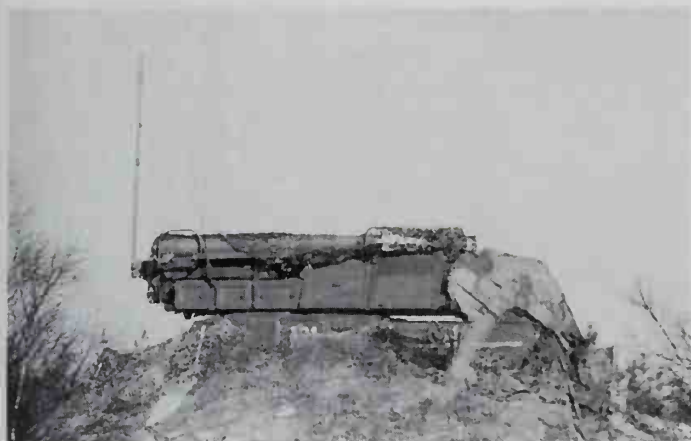


Another SA-11 associated radar, possibly for target acquisition, which is mounted on the same chassis as the SA-11. The designation of this system is believed to be 'Bill Board' (Jane's Intelligence Review)

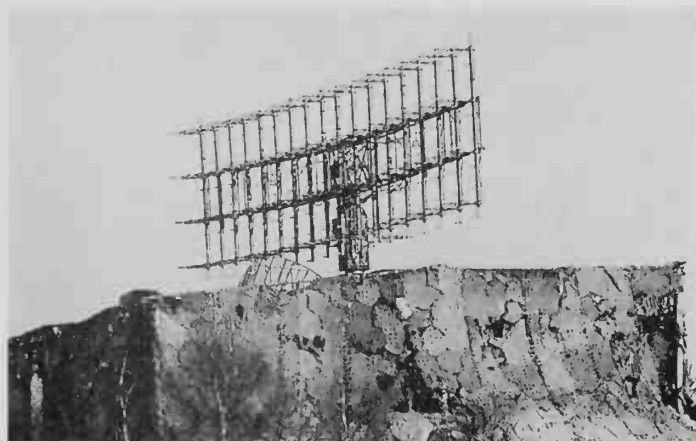


Provisional drawing of SA-11 'Gadfly' air defence missile launch vehicle (not to 1/76th scale) (Steven Zaloga)





SA-11 tracked launcher in a static position with the data link raised at the rear of the launcher and 'Fire Dome' radar lowered and covered at the front (Jane's Intelligence Review)



'Spoon Rest-D' surveillance radar used in conjunction with the SA-11. This has been positioned on a mound to give improved coverage against low level targets (Jane's Intelligence Review)

## SA-12a 'Gladiator'/SA-X-12b 'Giant' Low to High Altitude Missile Systems

### Development/Description

The SA-12a 'Gladiator' missile system was developed initially to augment the SA-4 'Ganef' in the SAM brigades at the Front level. The system entered operational service in 1986 and is apparently deployed in the southern and western USSR Military Districts in two slightly different versions, one for the conventional engagement of aircraft and the other for the anti-tactical ballistic missile (ATBM) rôle to engage weapons such as the Lance or Pluton. In May 1990 it was revealed that several dozen SA-12a SPU had been deployed in the middle of (East) Germany with Soviet Army/Front Level air defence units.

The conventional version of the Mach 3.0 two-stage SA-12a missile is 7.2 m long, 0.5 m in diameter and has a wing span of 1.35 m. Both the booster and sustainer rocket motors use solid fuel propellants. Launch weight is said to be around 2000 kg with a 150 kg HE-fragmentation warhead as the payload. Guidance is of the command type with semi-active radar homing for the terminal phase.

The 'Gladiator' SPU (*Samokhodnaya Pusskovaya Ustanovka*: mobile launcher unit) is based on the tracked MT-T tractor chassis which is derived from the T-64 MBT design and carries two cylindrical missile container-launchers that can be raised independently to the vertical for firing. The

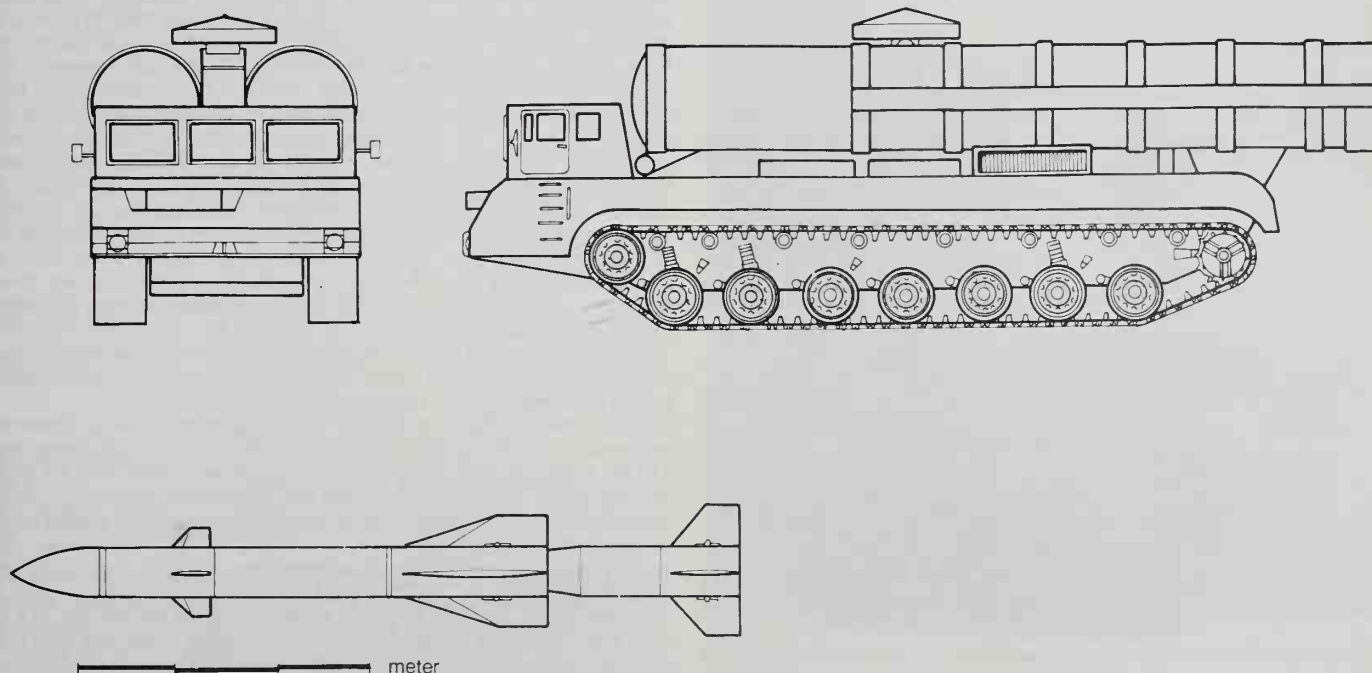
SPU also has a hydraulically operated telescopic missile guidance radar on the rear decking.

Within the battery there are three other vehicles based on the same chassis. At the battery HQ there is a single KShM (*Komandno-Shtabnaya Mashina*: command-staff vehicle), an SSNR (*Samokhodnaya Stantsiya Navedeniya Raket*: mobile missile guidance station) engagement radar (NATO code name Grill Pan) vehicle and a TZM (*Transportno-Zaryazhayushchaya Mashina*: transporter-loader vehicle) transloader.

The combined phased-array multiple tracking and fire control SSNR radar can be used to control the three SPUs of the battery but is more likely to be used to track targets handed over by the battalion and brigade level search radar systems. When in range these would then be passed on to the individual SPU guidance radars for engagement. The single TZM serves all three SPUs and carries four SA-12a reload rounds on its rear decking. It is probable that one of the three SPUs is configured slightly differently to the other two in order to carry the SA-12a ATBM variant.

A battalion appears to have three of these batteries and an HQ unit. The latter has two KShM vehicles and a single unit of the fourth vehicle type based on this chassis, the SSRT (*Samokhodnaya Stanitsiya Razvedki i Tselekazaniya*: mobile detection and designation radar station) long-range target search and acquisition radar vehicle (NATO code name Bill Board). Additional TZMs are also likely to be found at the battalion level.

A brigade has three of these battalions and an HQ unit with two SSRTs and three KShM vehicles. The minimum and maximum engagement limits



SA-12b 'Giant' transport-erector launcher vehicle (not to 1/76th scale) (Steven Zaloga)



Artist's impression of the various vehicles of the SA-12 low to high altitude surface-to-air missile family mounted on tracked chassis. In the background are the Bill Board warning and acquisition radar vehicle (on left) command vehicle (centre) and Grill Pan fire control radar vehicle (on right). The vehicle left foreground is the SA-12b launcher vehicle, the vehicle centre foreground is the reload carrier and the vehicle right foreground is the SA-12a launcher (Soviet Military Power 1986)



SA-X-12b 'Giant' SPU in firing position (US Department of Defense)

Deployment of the SA-12b may be different to the SA-12a system with three or four batteries per battalion and up to four battalions in a brigade. Each battery will have two or more SPUs with one or two TZMs, a KShM and an SSNR at the battery HQ. At battalion level there is a different SSRT radar system to that used by the SA-12a, another KShM vehicle and several more TZMs. The brigade HQ unit is believed to be similar in composition to that of the SA-12a brigade.

#### SPECIFICATIONS (SA-12a provisional)

CREW	4
COMBAT WEIGHT	20 364 kg
LENGTH	
with missiles	12.5 m
without missiles	8.63 m
WIDTH	3.42 m
HEIGHT	3.8 m
MAX SPEED	50 km/h
MAX RANGE	300 km
ENGINE	5-cylinder diesel developing 710 hp
ARMOUR	9 mm (max)

**Status:** The SA-12a, is in production and service with the Soviet Army. The SA-X-12b is in trials phase.

**Manufacturer:** Soviet state factories.

## SA-13 'Gopher' Low Altitude Surface-to-air Missile System

### Development/Description

The fully amphibious NBC-equipped SA-13 'Gopher' mobile SAM system with a range-only radar entered operational service in 1977. In the Soviet Army it has now virtually replaced the far less capable SA-9 'Gaskin'/BRDM-2 system on a one-for-one basis to improve the mobility of the anti-aircraft batteries in the Motorised Rifle and Tank divisions. The SA-13 was introduced into the Group of Soviet Forces Germany in the spring of

1980 and has since been seen in a number of other countries. The SA-13 'Gopher' has seen combat use in Chad (with Libyan forces) and in Angola with the MPLA and Cuban forces. In both areas examples have been captured by pro-western adversary forces. During the 1987/88 fighting in southern Angola a Fapla SA-13 system shot down a South African Air Force Mirage F-1AZ fighter-bomber. The SA-13 also saw service in the 1991 Gulf war with the Iraqi Army. High readiness Tank and Motorised Rifle Divisions field enlarged Regimental level air defence battalions of six ZSU-23-4 and six SA-13 'Gopher' vehicles. The normal air defence battalion for a regiment comprises four SA-13, four ZSU-23-4, two or three BTR-60PU-12 command posts and an MT-LBu 'Dog Ear' radar vehicle. In addition some of the Category 1 Divisions have had their air defence battalions of SA-13/ZSU-23-4 vehicles replaced by battalions fielding six 2S6 and six BMP-2 or SA-13. The BMP-2 apparently being used to transport regimental level SA-14/SA-16 manportable SAM teams with three launchers per BMP-2. The surveillance unit equipped with the F/G-band 5-man crew 'Dog Ear' radar vehicle remains the same. The 'Dog Ear' acquisition range is 80 km and the tracking range 35 km. The SA-13 is also organic to the Soviet Naval Infantry Brigade/Regiment air defence batteries having replaced the SA-9 TELs on a one-for-one basis.

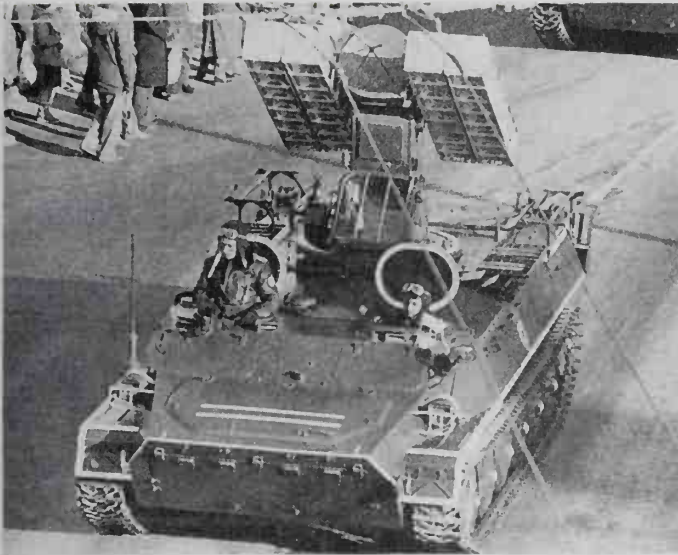
There are two versions of the SA-13 transporter erector launcher and radar (TELAR) variant of the MT-LBu vehicle in service, designated TELAR-1 and TELAR-2 by the US Army. Appraisal of both does not show any significant structural differences but it is known that the TELAR-1 carries four Flat Box B passive radar detection antenna units, one on either corner of the vehicle's rear deck, one facing aft and one between the driver's vision ports at the front, whereas the TELAR-2 has none. The TELAR-1 is apparently used by the SA-13 battery commander.

Known as the ZRK-BD Strela-10 system in Soviet service the 53.4 kg SA-13 missile (Soviet Military Index number 9M37) is 2.2 m long, 0.12 m in diameter with a 0.4 m wingspan and has a maximum speed of Mach 2. It carries a 5 kg HE warhead and is fitted with either an improved passive lead sulphide all-aspects infra-red seeker unit, which operates in two



Czechoslovakian Army SA-13 'Gopher' SAM system in travelling configuration clearly showing Flat Box B passive antenna between two front hatches





SA-13 'Gopher' SAM system of the Soviet Army with launcher arms elevated

individual frequency bands in the 1-5  $\mu$ m wavelength region to give high discrimination against infra-red countermeasures such as flares and decoy pods or a cryogenically cooled passive indium antimonide all-aspects infra-red seeker unit. Normally the TELAR carries four ready to fire SA-13 missile container-launchers and eight reloads in the cargo compartment but it has also been seen on numerous occasions with either SA-9 'Gaskin' container-launcher boxes in their place or a mixture of the two. This enables the battlefield features of both missiles to be utilised to the full by allowing the cheaper SA-9 (Strela-1) to be used against the 'easier' targets and the more expensive and sophisticated SA-13 (Strela-10) against the 'difficult' targets.

The missile mix also allows a choice of infra-red (IR) seeker types on the missiles for use against extremely low altitude targets as well as in adverse weather conditions.

Comparison of the missile characteristics are given in the table below:

MISSILE	Strela-1 (9M31M)	Strela-10 (9M37M)
WEIGHTS		
missile in container-launcher box	53.4 kg	70.2 kg
missile	30 kg	39.5 kg
DIMENSIONS		
container-launcher box	1900 x 290 x 290 mm	2330 x 290 x 290 mm
GUIDANCE	optical aiming	optical aiming
IR SEEKER TYPES	uncooled lead sulphide (PbS) near-IR homing type with no counter-measures capability	uncooled lead sulphide (PbS) near-IR homing type with counter-countermeasures capability against IR decoys or cooled indium antimonide (InSb) mid-IR homing type with counter-countermeasures capability against IR decoys
CONTROL METHOD	four movable canards and four rotor-controlled surfaces for roll stabilisation	
WARHEAD TYPE	HE-controlled fragmentation (2.6 kg HE and 460 fragments)	HE-fragmentation rod (2.7 kg HE and 100 rods)
LETHAL RADIUS	5 m	5 m
FUZING	impact and active xenon lamp proximity	
MAX MISSILE SPEED	Mach 1.5	Mach 2
MAX TARGET SPEED	300 m/s	420 m/s

The estimated minimum range of the SA-13 is 500 m and the maximum effective range of 5000 m with altitude engagement limits of 10 to 3500 m. An improved version, the Strela-10M2, with the 9M37M missile was captured in Angola by UNITA forces. Some vehicles have a pintle-mounted PKT 7.62 mm machine gun in front of the forward hatch for local protection. Other vehicles have been seen with additional support railings for the

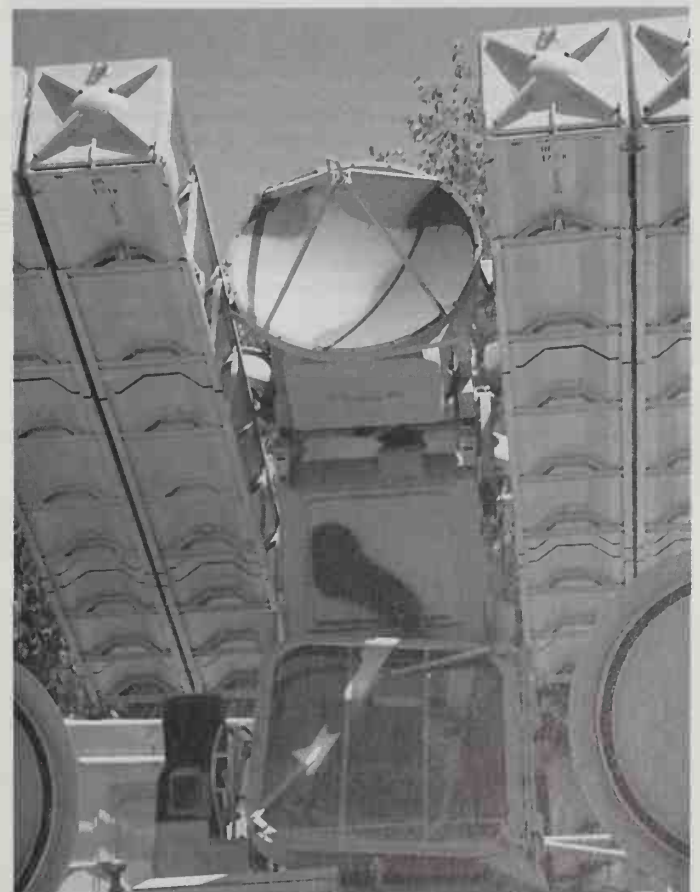


'Dog Ear' early warning and target acquisition MT-LBu radar vehicle which is used by SA-9 and SA-13 SAM units to provide target information

system on the rear deck. The minimum 10 km plus range circular parabolic radar antenna is located between the two pairs of missile canisters and is a simple range-only set to prevent wastage of missiles outside the effective range of the system.

The Soviet Industrial Index numbers for the system components are:

- (a) 9A35M2 - launcher vehicle
- (b) 9A34M2 - launcher vehicle
- (c) 9M37 - missile, latest version is 9M37M
- (d) 9B839M - system checkout vehicle
- (e) 9B915M - technical maintenance vehicle
- (f) 9U111 - a 1950 kg trailer-mounted 12 kW generator unit designed to feed power to up to four 9A35M2 or 9A34M2 launcher vehicles whilst conducting maintenance or training operations at a distance of up to 30 m by cable
- (g) plus drill and test equipment.



Close up of the gunner's position of an Iraqi SA-13 system showing tracking radar between two-round launchers and optical sight to left of gunner's window which is fitted with two wipers (Christopher F Foss)



Close up of SA-13 'Gopher' SAM system of the Iraqi Army from the rear (Christopher F Foss)



SA-13 'Gopher' SAM system with latest Strela-10M3 missiles deployed in the firing position, note the 7.62 mm machine gun at front of vehicle and additional fuel tank on hull side

#### Variants

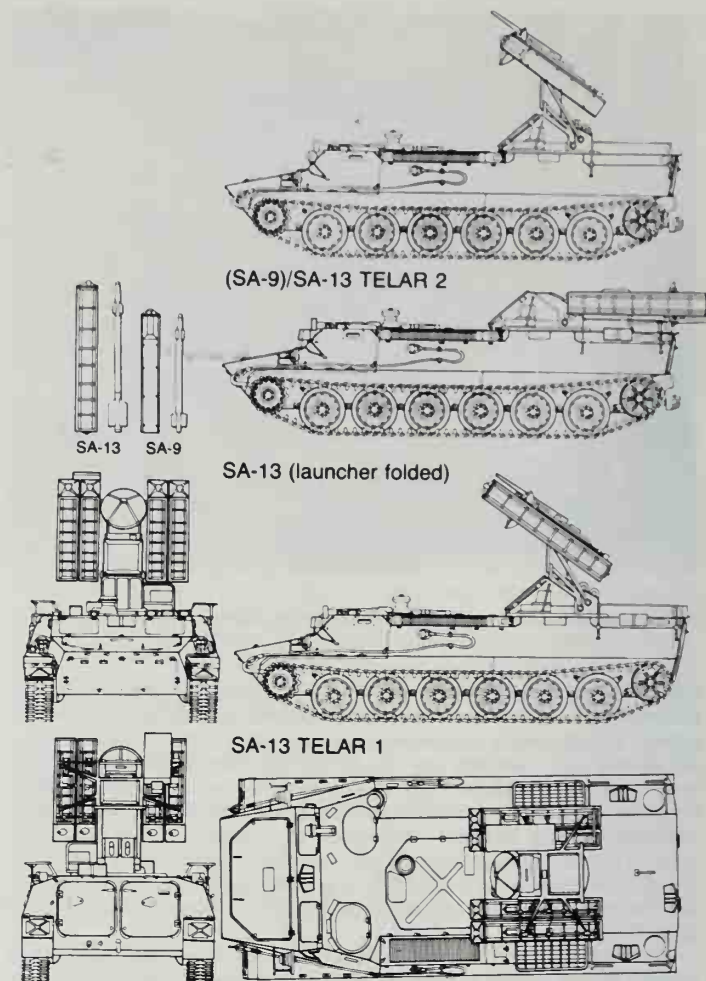
Apart from the Strela-10M2 the Soviets have deployed another version of the SA-13 known by the designation Strela-10M3. This is designed for use in the mobile battle and to defend troops on the march from low level attacks by aircraft and helicopters, precision-guided munitions and other flying vehicles such as reconnaissance RPVs.

The major change is the adoption of a dual mode guidance system for the missile seeker - optical 'photocontrast' and dual band passive IR. The missile accommodating this system is the 9M333. This weighs 42 kg at launch and when in its container-launcher the box-like canister has a total mass of 74 kg. Target acquisition range using the optical 'photocontrast' channel is between 2000-8000 m whilst for the IR channel it is between 2300-5300 m. Altitude engagement limits are from 10 m up to 3500 m at a maximum range of 5000 m. Average missile speed is 550 m/s. The HE-fragmentation rod warhead weighs 5 kg in total (including 2.6 kg of HE) and uses both contact and active laser proximity fuzing systems. The actuation radius of the proximity fuze is up to 4 m.

The dual mode passive optical 'photocontrast'/IR seeker ensures good IR decoy counter-countermeasures discrimination capability and optimum use of the system against diverse and extremely low altitude targets as well as in adverse weather conditions.

#### SPECIFICATIONS

CREW	3
ELEVATION/DEPRESSION	+80°/-5°
TRAINING RATES	
elevation	0.3-50°/s
azimuth	0.3-100°/s
COMBAT WEIGHT	12 300 kg
LENGTH	
with missile	6.6 m
without missile	6.45 m



SA-13 'Gopher' Mobile SAM system (not to 1/76th scale) (Steven Zaloga)



SA-13 'Gopher' SAM system with latest Strela-10M3 missiles in the travelling position with missiles retracted and showing Flat Box B passive radar detection system between commanders and drivers windscreen

WIDTH	2.85 m
HEIGHT	
firing position	3.8 m
travelling	2.3 m
MAX SPEED	
road	61.5 km/h
water	6 km/h
FUEL	450 l
RANGE	500 km
VERTICAL OBSTACLE	0.7 m
TRENCH	2.7 m

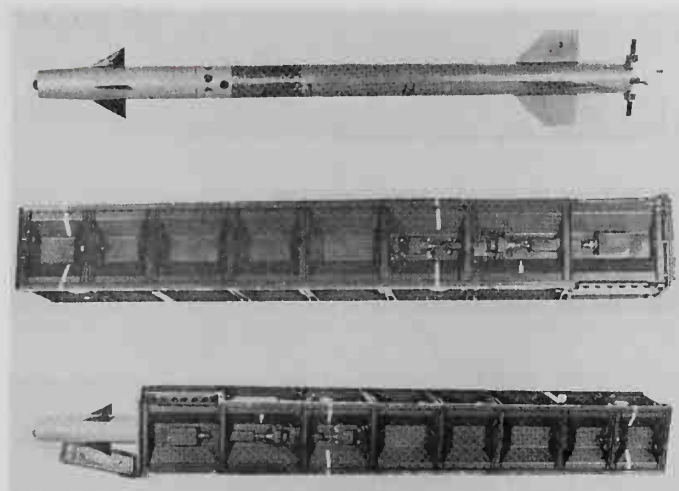


ENGINE	YaMZ-238V diesel developing 240 hp
ARMAMENT	4 × SA-13 missiles
UNIT OF FIRE	12 missiles
ARMOUR	7 mm (max)

**Status:** In production. In service with the following countries:

Country	Quantity	User
Afghanistan	16+	army
Algeria	32+	army
Angola	30+	army
Bulgaria	20+	army
Cuba	40	army
Czechoslovakia	100+	army
Hungary	12+	army
Iraq	n/av	army
Jordan	20	air force
Libya	60+	army
Poland	60+	army
Syria	60+	army
USSR	1200+	army, naval infantry

**Manufacturer:** Soviet state factories



Latest SA-13 Strela-10M3 missile out of its launcher (top), launch container (centre) and emerging from launch container (lower)

## SA-15 Low to Medium Altitude Self-propelled Surface-to-air Missile System

### Development

The 'Antey' Scientific Industrial Corporation has developed through the 1980s a mobile highly automated integral SAM system, designated the ZRK Tor (Russian for the Norse folklore god Thor), to replace the Kub (SA-6) and ZRK Osa (SA-8) systems at Divisional level. The Tor has been given the US/NATO designation SA-15 and is considered by the Soviets to be capable of engaging not only aircraft and helicopters but also RPVs, precision-guided weapons and various types of guided missile.

Regimental composition is not available at the present time but it is known that the ZRK Tor can be used with an air defence command post vehicle (such as the Rangir - based on the hull and chassis of the ACRV (Armoured Command and Reconnaissance Vehicle)) which can also control 2S6 systems and manportable SAM teams equipped with SA-7 'Grail', SA-14 'Gremlin', SA-16 'Gimlet' or SA-18 weapons. Long-range surveillance information being provided by an MT-LBu 'Dog Ear' radar vehicle.

### Description

The chassis of the vehicle is almost identical to that used for the 2S6 self-propelled hybrid air defence system and is based on the GM-569 tracked vehicle. The three man crew comprises the vehicle commander, system operator and vehicle driver. All of whom are seated at the front of the vehicle with the large box-like unmanned turret in the centre and the engine compartment at the rear. The driver is located on the left side of the vehicle front and has a windscreen to his immediate front which if required may be covered by a hatch cover that is hinged at the top. This arrangement is similar to that used previously on the Kub (SA-6) and Shilka (ZSU-23-4)

vehicles. The other crew members are seated to his rear with the system PPI console on the right and the launch controls to the left.

The vehicle suspension consists of six dual rubber tyred roadwheels either side with the idler at the front, drive sprocket at the rear and three return rollers. An auxiliary gas turbine is fitted which powers a 75 kW generator allowing the main diesel engine to be shut down when the system is deployed so as to conserve fuel.

The Tor is not amphibious although it is airortable. An NBC system is fitted as standard as is a built-in training system.

On top of the turret rear is the surveillance radar antenna assembly which is swung through 90° to the horizontal position for extended travelling purposes. The 3D pulse Doppler electronically beam steered radar operates in the E/F-band and provides the range, azimuth, elevation and automatic threat evaluation data on up to 48 targets for the associated digital fire control computer processing system.

Automatic track initiation on the 10 targets assessed as the most dangerous can be performed. These are then categorised and prioritised in order of threat by the computer for the engagement. All the operator has to do is to reconfirm the choice of the highest priority target choice and track this selected target before pressing the 'fire' button.

The maximum radar range quoted is 25 000 m but the fast reaction time – five to eight seconds which includes the fire control computer assigning the target priority – suggests that it is probably greater than this.

At the front of the turret is the phased-array pulse Doppler G/H-band tracking radar. The beams of which are also electronically steered. This is capable of tracking two targets simultaneously, travelling at speeds of up to 700 km/h in any kind of weather and at any time of day or night irrespective of threat ECM operations. The antenna assembly can also be folded down for travelling purposes. Mounted on the top left of this radar is a small vertical pointing antenna which is believed to serve in initially gathering the



SA-15 Tor SAM system in operating configuration with turret traversed right



SA-15 Tor in travelling configuration with turret traverse to rear



SA-15 Tor SAM system in operating configuration with all antenna erected

missile after launch before being handed over to the main tracking/guidance system.

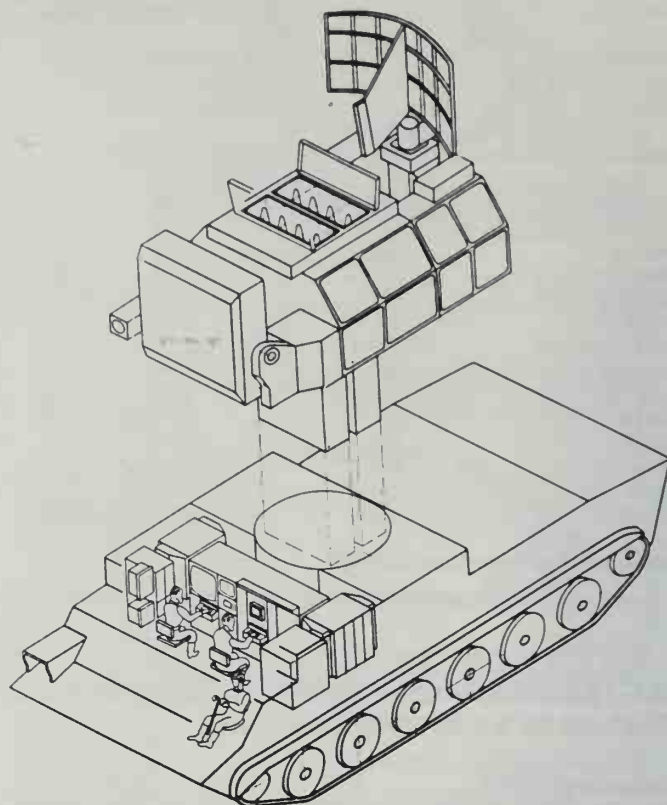
Lower down on the right side of the tracking radar is an autonomous automatic TV tracking system with a range of 20 000 m that complements the tracking radar and enables the system to operate in battlefield clutter and heavy ECM environment.

Target radar surveillance is carried out on the move but the vehicle would normally come to a halt for missile launch. Although it is an autonomous system it can be interfaced into an air defence network as it carries a specialist coded data link for such purposes. The Soviets also state that its design is flexible enough to accommodate other manufacturers command and control equipment if a customer so wished.

The missile area comprises a box-like container that extends down below the level of the hull top and which carries two groups of four ready to fire missiles in the vertical position. Each missile is in its own sealed container-launcher box and requires no maintenance. Reloading of the system is performed by a specialist transportation/loader vehicle.

The single stage solid propellant missile has a maximum speed of 850 m/s and is fitted with a 15 kg HE-fragmentation warhead that is detonated by a proximity fuzing system. Provisional missile details are length 3.5 m, diameter 0.735 m and launch weight 170 kg.

On firing a cold launch ejection system propels the missile upwards to a height of 18-20 m where thruster jets ignite and turn the weapon onto the target bearing. The main sustainer rocket motor then cuts and the missile is command guided to the intercept point where the proximity fuze is triggered.



Position of main components of the SA-15 Tor SAM system with magazine covers in open position to reveal vertically launched missiles

Effective range limits are from 1500 to 12 000 m with target altitude limits being between 10 and 6000 m. The maximum manoeuvring load factor limit on the weapon is 30 g.

**Status:** Production. In limited service with the Soviet Army.

**Manufacturer:** 'Anatey' Scientific Industrial Organisation.

Enquiries to: V/O 'AVIAEXPORT' 48 Ivan Franko Street, 121351 Moscow, Russian Republic.

Telephone: 417-00-55

Cable: Moscow, 351, Aviaexport

Telex: 411929

## SA-X-17 Low to Medium Altitude Surface-to-air Missile System

The Soviet Union is currently developing a new mobile SAM system designated SA-X-17 in the US designation series to augment and eventually replace the SA-11 'Gadfly'. Few other details are available at present, except it uses the same launch vehicle chassis and has a similar configuration

to the SA-11 'Gadfly'. The surveillance radar has the NATO code name 'Snow Drift' and is also carried on the modified GM-569 tracked vehicle chassis.

**Status:** Development phase. Initial work believed to have started in the early 1980s with the first Western intelligence reports concerning the system emerging in 1986-87. Troop trials apparently started in 1988 with service introduction due in 1992-93.

## SA-19 Low to Medium Altitude Surface-to-air Missile System

### Development/Description

The Soviet Union has developed a tube-launched hypersonic low altitude SAM for use on its 2S6 (NATO/STANAG code name SPAAG M1986) (qv) hybrid tracked air defence gun/missile vehicle. The missile, which is 2 m long and 0.15 m in diameter, is mounted in two elevatable launcher tube pairs on either side of the turret and is designed primarily for use against

NATO anti-tank helicopters. Guidance is thought to be SACLOS with an infra-red terminal homing seeker. Maximum range is between 7-10 000 m with one of the vehicle's two roof sights probably used for target acquisition/aiming. The missile is thought to have the Soviet Military Index number 9M311.

**Status:** Production. In service with the Soviet Army (on 2S6 anti-aircraft vehicles).

**Manufacturer:** Soviet State factories.



## UNITED KINGDOM

### British Aerospace Tracked Rapier Low Altitude Surface-to-air Missile System

#### Development

Development of the Tracked Rapier began early in 1974 by the Guided Weapons Division of the British Aircraft Corporation, now British Aerospace (Dynamics). After studying the tracked vehicles on the world market the FMC M548 tracked cargo carrier was chosen. It is a member of the M113 family of APCs which is in service with over 40 countries and has been built in larger numbers than any other military vehicle in the West. In September 1974 it was announced that the Imperial Iranian Ground Forces had placed an order worth \$400 million for 72 Tracked Rapier systems.

By late 1978 development of the Tracked Rapier was advanced in preparation for production. Early in 1979 the new Iranian Government cancelled a large number of defence contracts including that for the Tracked Rapier. Following evaluation by the British Army, the MoD placed an order for 50 Tracked Rapiers in June 1981, the first of which was accepted into service in January 1983. A further 20 were ordered in the post-Falklands defence review. Current army planning is for three Light Air Defence Regiments, the 12th, 16th and 22nd, to be equipped with both Tracked and Towed Rapier. A regiment will have two batteries of each system with 12 firing units per battery. The basic towed Rapier is in service with Australia, Brunei, Indonesia, Iran (Army and Air Force), Oman, Qatar, Singapore, Switzerland, Turkey, United Arab Emirates (Abu Dhabi), United Kingdom (Army and Air Force), United States (Air Force) and Zambia. Of these, Indonesia and Zambia have Optical Rapier, the others have Blindfire Rapier. By 1991 signed orders for Rapier and Tracked Rapier had exceeded 700 fire units, 27 000 missiles and 350 Blindfire radars.

The missile with Towed Rapier has seen combat use in the 1982 Falkland Islands Conflict and, it is believed, with Iran against Iraq during the border skirmishes of the 1970s and the Gulf War.

Tracked Rapier with a number of modifications, including the installation of 12.7 mm M2 HB machine guns, was one of the four contenders for the US Army FAADS-LOS-FH competition which was won by the ADATS system late in 1987.

Under the British Governments 'Options for Change' programme the air defence regiments of the Royal Artillery are to be re-organised in four regiments, two with Rapier towed systems and two with the Stormer/Starstreak high velocity missile system with the Tracked Rapier expected to be phased out of service from the mid-1990s.

#### Description

The Tracked Rapier Launch Vehicle (TRLV) is based on the M548 chassis which for this role is designated the RCM 748. The crew of three is seated in the aluminium armoured cab which protects them from small arms fire and shell splinters. The driver is seated on the left, commander in the centre and the tracker operator on the right. There is a door in each side of the cab and bulletproof windows in the front and sides of the cab. Both the driver and commander can be provided with night vision equipment and smoke dischargers are mounted front and rear.

A hatch is provided for the commander. When surveillance radar data is not available the commander can acquire and engage a target visually by using the standard fit Ferranti Helmet Pointing System. Using this helmet sight the commander can routinely acquire targets and then slew the



*Tracked Rapier vehicle commander using Ferranti Helmet Pointing System*

optical sight onto the bearing and elevation within 0.5 second. This reduces the normal visual engagement time by up to five seconds. At the commander's station inside the vehicle cab are the Tactical Control Unit (TCU), built-in test equipment and the radios, all of which are on anti-vibration mountings. The vehicle commander acts as the tactical controller in an engagement.

The TCU provides tactical control facilities and is connected to the launcher and the optical tracker. The TCU is divided into 32 sectors in azimuth, each sector thus covering 11.25°. By operating sector switches, blind areas can be established to provide safe channels and heights for friendly aircraft or to set in priority arcs of fire for the fire unit, should this be required.

A day and night capability is provided by the addition of a class 2 common module based 10 km range thermal imager with associated electronics and a compressed air-cooling unit mounted on the Tracker rotary head. The operator can select optical or thermo-optical as required. The tracker, designated as TOTE (Tracker Optical Thermally Enhanced), can be programmed for an automatic passive search programme in addition to its day and night tracking role. TOTE is mounted on anti-vibration mounts in the roof of the cab on the right side in place of the optical tracker. When deployed the tracker is raised into the operating position and when not required can be retracted into the cab and covered by an armoured hatch. The operator tracks the target either using the optical channel or TOTE by means of a joystick control to establish a sightline to the target. A TV system collimated with the target tracking system is used to gather the missile onto the sightline and then to measure the displacement of the missile from the sightline during flight so that correcting commands can be generated and sent to the missile automatically. The operator is provided with a biocular sight for target tracking and has the few simple controls



*Tracked Rapier Launch Vehicle in travelling configuration (Christopher F Foss)*



*Tracked Rapier Launch Vehicle with launcher traversed to right (Christopher F Foss)*



*Tracked Rapier Launch Vehicle during British Army trials in the Hebrides. In this firing, the Mk 1 missile was launched over the cab with microwave command link antenna raised to obtain unobstructed view*

required to operate the system at the control station. A monocular sight at the rear of the tracker allows either an instructor to monitor students' performances during training in the field or the fitting of a CCTV camera.

Immediately behind the cab there is an air-cooling unit and the cab also has a heater. The diesel generator set is to the rear of the engine bay and uses an HD 30 diesel engine identical to that in the Chieftain MBT. To the rear of the cab is the shield which protects the forward part of the vehicle from blast when a missile is launched.

Installed on anti-vibration mounts at the rear is the launcher which has four missiles on each side with 25 mm armour protection. The turntable and base of the launcher are also protected to APC standards by armour plate. The J-band command antenna is mounted on an elevating mechanism which, when raised, allows missiles to be launched and guided at low altitudes over the cab. Under a radome, on the armoured turntable, are the pulse Doppler F-band all-weather 11.43 km range surveillance radar antenna that rotates once every second, and the IFF antennas and interrogator. The radar transmitter/receiver is mounted in the base of the launcher unit. The turntable can rotate through 360°.

The Rapier Mk 1 missile is identical to that used in the towed Rapier system and is manufactured as a round of ammunition and requires no maintenance, testing or servicing once it has left the ordnance depot except for routine changing of desiccators. The missile has a shelf life of at least 10 years when stored in controlled conditions.

The missile consists of four main sections: warhead, guidance, propulsion motor and control. The section contains the 1.4 kg warhead, safety and arming unit and crush fuze. The guidance section is in two parts, the electronics pack and the instrument pack. The propulsion unit is an integral two-stage booster motor and gives the missile a maximum speed of over Mach 2. The rear control section contains the hot gas-driven control surface actuation mechanism which controls the missile in flight and flares to facilitate TV gathering and tracking. The two-stage, solid fuel motor missile is 2.24 m long, has a body diameter of 0.133 m, wingspan of 0.381 m and weighs 42.6 kg. The missile has an effective range of 247 to 7000 m and can operate from very low levels to over 3000 m. The warhead is of the semi armour-piercing type with a 0.5 kg HE charge and a contact fuze. The missile has proved to be extremely agile and to be able to pull high *g* turns out to its maximum range against both manoeuvring and fast crossing targets. Once the eight missiles have been fired the launcher can be reloaded by hand in under five minutes. The average Single Shot Kill Probability of the system is over 70 per cent which has been demonstrated in MoD practice range firings.

From a tactical move the launcher can be put into action and begin an engagement within 15 seconds of coming to a halt; reaction time for the first missile is five seconds, the second two seconds, with the time out of action 20 seconds.

A typical engagement takes place as follows. The surveillance radar aerial mounted on top of the launcher is continuously rotating 360° looking for aircraft which come within its range. When detected an aircraft is automatically interrogated by the IFF system. If no friendly reply is received the operator is alerted by an audible signal in his headphones. At the same time the rotating head on the optical tracker automatically lines up with the target in azimuth followed by the launcher turntable with the missiles at the rear of the vehicle. If necessary the operator then undertakes an elevation

search to acquire the target. Once the operator has acquired the target he switches to the track mode and begins to track the target using a joystick. He can then identify the target aircraft visually. Information from the optical tracker and the surveillance radar are fed into the system computer in the launcher. This information is used to calculate whether or not the aircraft is within the range of the system. When the aircraft comes within firing range a lamp signal appears in the operator's field-of-view and he immediately presses the firing button to launch a missile. The computer also calculates and sets the launcher towards the optical line-of-sight. The missile is automatically gathered and guided along the sight line by the TV system until impact. During missile flight the operator's only task is to keep track of the target. When the engagement is finished the operator may switch back to search so that another engagement sequence can begin immediately if required. Or, a second missile may be fired at the same target or another target in the operator's field-of-view.

To give the system all-weather capability a Marconi Radar and Control Systems Blindfire radar can be added. In operation the Blindfire monopulse radar employs differential tracking of both the missile and the target using a very narrow pencil beam to achieve the accuracy required. Frequency agility is used to reduce the effect of target glint and ECM. Each TRLV is also accompanied by an M548 Tracked Rapier Support Vehicle (TRSV) with a crew of two and 20 reload Rapier missiles in their travelling containers.

A Forward Area Support Team (FAST) vehicle, which is a modified M548, has also been developed. This has a crew of two, VHF radio, front-mounted crane, test equipment and spare line-replacement units in order to provide the maintenance and support requirements of Tracked Rapier in the field. Twelve FAST vehicles have been delivered to date.

Modifications to give Tracked Rapier a night capability are already under way. The incorporation of a thermal imager in addition to the optical target tracking channel allows completely passive night operations up to the moment of missile launch. The Tracker, Optical, Thermally Enhanced (TOTE) programme involves additional equipment being mounted on the rotary head of the optical tracker. The Class 2 common module based thermal imager is on an elevating mount on one side of the tracker with a compressed air-cooling bottle on the other side, and electronic units mounted front and rear. The operating sequence for night engagements remains essentially as described earlier. The current optical only Tracked Rapier vehicle is designated the SP Mk 1A by the British Army and those retrofitted with TOTE become the SP Mk 1B.

Tracked Rapier retains the cross-country performance and amphibious capability of the vehicle in the original role. It is easily airtransportable, one tracked fire unit being carried combat-ready in a C-130 aircraft. With its low profile and rotating aerial hidden by a radome the fire unit is easy to conceal, has a low IR signature, and is capable of passive surveillance when required. The system is designed to be operated in NBC clothing.

The system will also be compatible with the Rapier Mk 2 missile that is being developed for the Rapier 2000 programme which was initiated in late 1986 for deployment in Towed form during the mid-1990s. The missile will be available in two versions: the Mk 2A semi armour-piercing round and the Mk 2B with a fragmentation warhead and proximity fuze.

THORN EMI Electronics produced a small pre-production order of the active infra-red (IR) fuzes for the Rapier Mk 2B missile in 1990. Full production of the fuze began in mid-1991 as a milestone objective in the £10 million development and initial production contract awarded to the company in 1986.

The fuze system comprises an IR laser transmitter and four quadrant receiver optics units, coupled with intelligent signal processing to determine the optimum range to target position at which detonation of the fragmentation warhead is to be initiated.

#### SPECIFICATIONS

CREW	3
COMBAT WEIGHT	14 010 kg
POWER-TO-WEIGHT RATIO	14.89 hp/t
GROUND PRESSURE	0.63 kg/cm <sup>2</sup>
LENGTH	6.4 m
WIDTH	2.8 m
HEIGHT	
optical tracker raised	2.78 m
airportable	2.5 m
GROUND CLEARANCE	0.41 m
TRACK	2.159 m
TRACK WIDTH	381 mm
LENGTH OF TRACK ON GROUND	2.819 m
MAX SPEED	
road	48 km/h
water	5.6 km/h
FUEL CAPACITY	398 l
CRUISING RANGE	300 km
FORDING (with screen)	amphibious
GRADIENT	60%
SIDE SLOPE	30%



VERTICAL OBSTACLE	0.609 m
TRENCH	1.676 m
TURNING RADIUS	4.3 m
ENGINE	Detroit Diesel Model 6V-53 6-cylinder liquid-cooled diesel developing 210 hp at 2800 rpm
TRANSMISSION	Allison TX-100 3-speed, torque converter
SUSPENSION	torsion bar
ELECTRICAL SYSTEM	24 V
ARMAMENT	8-round launcher for Rapier SAM
SMOKE DISCHARGERS	yes (front and rear)

**Status:** Production complete. A total of 72 Tracked Rapiers have been delivered to the British Army.

**Manufacturer:** British Aerospace (Dynamics) Limited, Six Hills Way, Stevenage, Hertfordshire, SG1 2DA, UK.  
Telephone: (0438) 312422  
Telex: 825125, 825126



*Forward Area Support Team (FAST) vehicle*

## British Aerospace Laserfire Low Altitude Surface-to-air Missile System

### Development

The Laserfire low altitude surface-to-air missile system has been developed as a private venture by British Aerospace (Dynamics) for the gap in the market between portable systems such as the Stinger, RBS 70 and Mistral and the more expensive all-weather systems such as the ADATS and Crotale New Generation.

Feasibility and project definition of Laserfire was carried out in 1982 with full development of the system starting in 1983. The conceptual proving of the two main sensors, the surveillance radar and the laser tracker, were key points in the programme and between 1984 and 1986 successful trials were carried out to illustrate the performance of each.

During the trials the surveillance radar, developed jointly by Racal and BAe, was shown to have the required detections at ranges of 10 km and beyond, and the essential accuracy for laying-on the laser tracker. The detection capability of the tracker was demonstrated through a number of auto-tracking trials against a range of small targets.

The first and successful auto-track trials in 1986 brought together for the first time both the laser tracker and the complete servo-driven launcher turntable under full computer software control.

By mid-1989 development of the Laserfire system was virtually complete and five firing trials, all direct hits, had been achieved. Of these, two were against a small Hayes-towed gunnery target and three against a static sightline balloon target (simulating either a head-on aircraft or a hovering helicopter).

The last of the development trials employed successfully the full automatic engagement sequence that Laserfire offers. The radar was used to acquire automatically the target and automatic handover to the laser tracker and hence subsequent auto-track was rapidly achieved. With the only operator

intervention being the pressing of the fire button, the missile was successfully guided for direct hit against a small Hayes target.

During the development programme, the performance of the system has been tested at various extremes of environment. Rough road, trundling and hot and cold temperature ( $-30$  to  $+50^{\circ}\text{C}$ ) trials were carried out successfully.

Late in 1989 acquisition and tracking trials against a wide variety of different aircraft types and trajectories was completed. These trials, carried out in the UK, together with a final set of development firings in the Middle East during early 1990 provided the final confirmation that Laserfire can engage the air threat.

Total cost of the Laserfire programme was about £50 million of which some £14 million was for the Racal Gustav radar system which was 50 per cent funded by BAe and similarly funded by Racal.

A total of six prototype pallet systems have been built, two complete prototype A-model units followed by four B-model fire units built to pre-production standard.

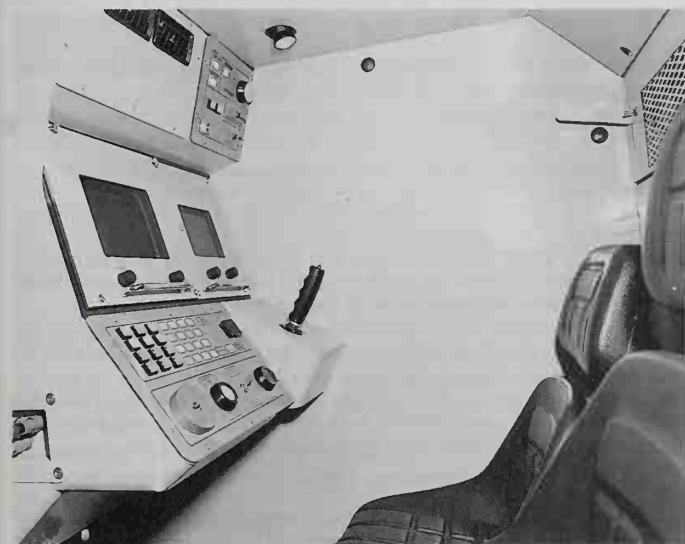
Although prototype systems have been carried on a modified AWD ( $4 \times 4$ ) truck chassis, the system can be installed on virtually any truck of this type as well as armoured vehicles including the Alvis Stormer, FMC M548 and the GKN Defence Warrior.

In August 1991 British Aerospace (Dynamics) stated that it was building two Laserfire units to production standard to ensure immediate delivery to customers.

### Description

Laserfire is a complete fire unit on a turntable pallet which can be carried and operated from a vehicle, such as a AWD ( $4 \times 4$ ) truck, or the pallet alone can be deployed on the ground for static defence. It can be used as a stand-alone unit or as part of a wider air defence network.

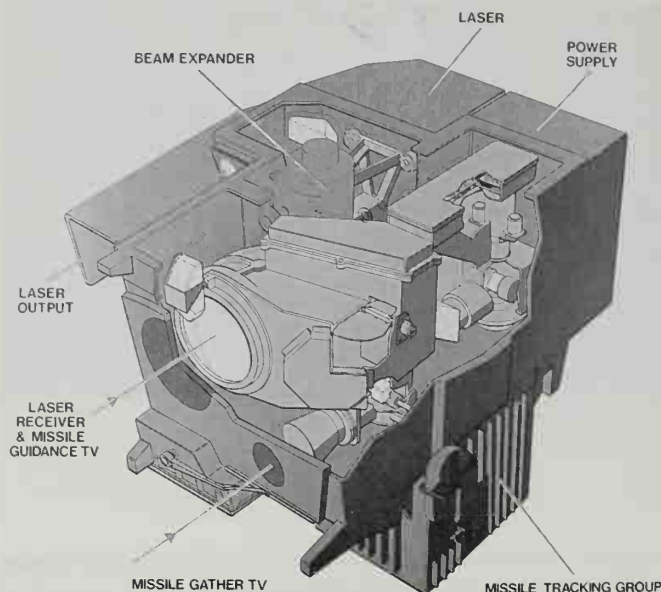
In addition to the Rapier missile there are four key elements of the fire unit. First the advanced M-band millimetric surveillance radar developed jointly by Racal and BAe which has a target detection range of 10 km and



*Interior of the two-man crew cab of the BAe Dynamics Laserfire low level air defence system*



*Pallet-mounted Laserfire which can also be removed from its carrier chassis and deployed as stand-alone unit as shown*



Cutaway drawing of the BAe Dynamics Laserfire tracker unit showing main components

up to 3 km altitude. This provides target azimuth and elevation information and detects both fixed-wing and helicopter aircraft. It continues to work in severe electronic countermeasures and is immune to attack by anti-radar missiles.

Second is the automatic combined target and missile tracker. A narrowbeam precision laser is used to auto-track the target and a TV is used to track the missile in flight, sending guidance command signals to steer the missile onto an intercept trajectory even against highly manoeuvrable targets.

Third is the high power electric servos using state-of-the-art solid-state circuits. The turntable and gimbal-mounted tracker are driven rapidly and reliably with extreme precision to the target bearing. A twin-axes gyroscope is used to stabilise the tracking sightline, eliminating the need for steadying jacks.

Fourth is the military computer which is the heart of the Laserfire system. This system processor co-ordinates and controls all of the automatic functions of the fire unit as well as providing a clear easy-to-follow man/machine interface for the operator. In addition to all of the operational functions the computer provides a comprehensive BITE capability for system confidence and easy maintenance and an interactive training mode to enable the crew to practice target engagements. It has a day and night capability to engage attacking aircraft or helicopters. The Rapier Mk 1 missile, common to other Rapier variants, weighs 42.6 kg and can be reloaded by the crew quickly and easily without cranes or special handling equipment. The missile has a range of 247 to 7000 m to give a high lethality (averaged over 70 per cent Single Shot Kill Probability) over an area of approximately 140 km<sup>2</sup>, against directly approaching and fast crossing targets. The system is also compatible with the other Rapier missile variants described in the previous *Tracked Rapier* entry. It will also fire the new Mk 2 missile that has replaced the Mk 1 in production.

When targets are detected by the millimetric Surveillance Radar, the pallet automatically slews in azimuth to the bearing, and the gyro-stabilised pulsed GEC Ferranti Defence Systems Type 629 Nd:YAG Laser Tracker



British Aerospace (Dynamics) Laserfire launching a missile during Middle East trials

unit, automatically put on in elevation, acquires and tracks the target. When the computer instructs the operator to fire, he presses the fire button to launch the missile. A TV camera in the laser tracker displays the scene within the cabin on a screen at up to  $\times 13$  magnification and automatically tracks the missile flares and measures any divergence of the missile from the laser sight line. These measurements are converted into commands to return the missile to the Sight Line and sent to the missile by the command aerial mounted on the cab. The whole engagement from detection to target impact is automatic, although the operator can override the computer at any time, for instance by rejecting a target selected by the computer in favour of another of the possible seven shown on his visual display unit. In periods of radar silence targets can be engaged by the detachment commander acting as air sentry putting the Laser Tracker onto the target with an Auxiliary Sight or Pointing Stick mounted on the cab.

System reaction time is fast enough to cope with either high speed low flying aircraft or helicopters which may use terrain screening until they are exposed at short range. Built-in test facilities in the weapon system monitor performance and can diagnose faults to line-replaceable units, allowing these to be changed by the operator when required, thus reducing the need for technicians to operate in the forward area of the battlefield.

#### PALLET SPECIFICATIONS

LENGTH	3.3 m
WIDTH	2.4 m
HEIGHT	1.9 m
WEIGHT	2000 kg

**Status:** Development complete. Two Laserfire fire units are being built to production standard to ensure immediate delivery to customers.

**Manufacturer:** British Aerospace (Dynamics) Ltd, Six Hills Way, Stevenage, Hertfordshire, SG1 2DA, UK.

Telephone: (0438) 312422

Telex: 825125 825126

## Shorts Starstreak Low Altitude Self-propelled High Velocity Missile System

### Development

In order to fulfil the British Army's General Staff Requirement (GSR) 3979 supplementing Rapier in the battlefield role of engaging late-unmasking close support aircraft and ATGW-equipped hovering helicopters, the Ministry of Defence originally approached 11 different companies to provide a new High Velocity Missile (HVM) design. Of these, British Aerospace and Short Brothers were each awarded a 12-month project definition contract in 1984. In late 1986 the latter was awarded a £225 million fixed price contract to cover the development, initial production and supply of the Starstreak HVM weapon.

Under the British Governments 'Options for Change' plans, the Royal Artillery will have four air defence regiments, two equipped with Rapier

(towed) and two with the Starstreak High Velocity Missile (HVM) system, with one Rapier and one Starstreak regiment based in UK and one Rapier and one Starstreak regiment based in Germany.

The two Starstreak High Velocity Missile Regiments are the 12th Air Defence Regiment, Royal Artillery with three batteries, and the 47th Air Defence Regiment, Royal Artillery also with three batteries.

A total procurement of 151 vehicles is envisaged with first deliveries taking place in the early 1990s. Late in 1990 it was announced that production of the Starstreak HVM system would be stretched.

### Description

The Stormer in the Starstreak launcher configuration carries a crew of three, driver, gunner and commander, with eight ready to fire rounds in two armour-protected servo-controlled containers on the vehicle roof. Collocated with these is the THORN EMI passive infra-red Air Defence Alerting Device (ADAD). Forward of the launcher is the gunner's surveillance, firing and





*Shorts Starstreak HVM system on Alvis Stormer APC showing THORN EMI ADAD on top of launcher*

target tracking turret which is fitted with an Avimo servo-controlled target acquisition and tracking sight.

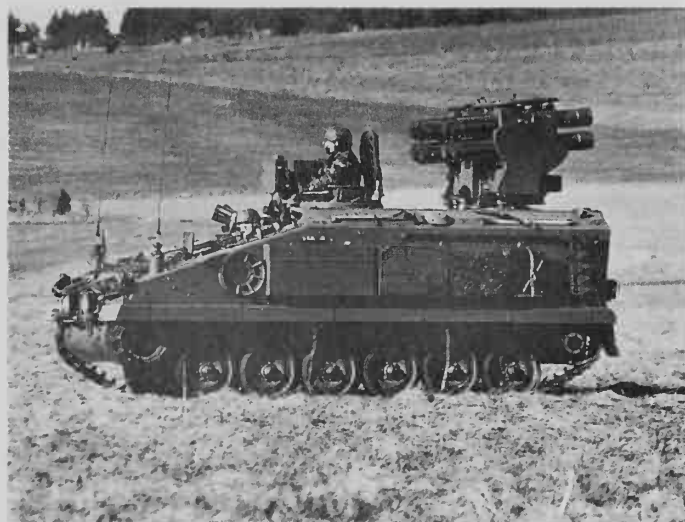
The ADAD provides for detection of targets, their prioritisation, operator alerting and automatic pointing of the Avimo weapon sight at the priority target in azimuth and elevation.

It is based on existing infra-red system technology and offers a 24 hour operational capability for Starstreak which is totally independent of optical visibility, being able to 'see' through battlefield smoke, haze and mist.

The system comprises three lightweight modules:

- (a) Scanner Infra-red Assembly (SIA)
- (b) Electronic Pack Processor Unit (EPPU)
- (c) Electronic Pack Remote Display Unit (EPRDU).

A guidance beam transmitter is also housed in the sight unit and this is collimated to the target sight line. A total of 12 reload rounds are carried within the hull and these can be used to reload the missile containers or to provide a shoulder-launch or lightweight multiple launcher capability off vehicle. For these roles an additional aiming unit is carried.



*Shorts Starstreak HVM system on Alvis Stormer APC*

A full description of the missile and method of operation is given in the *Manportable Surface-to-air missiles* section.

Shorts has offered the Starstreak HVM system on the Boeing Avenger air defence vehicle (qv entry this section) to the US Army as a candidate for inclusion in the FAADS network at some future date.

**Status:** Entering production for the British Army.

**Manufacturers:** Prime contractor: Short Brothers PLC, Defence Systems Division, Castlereagh, Belfast BT6 9HN, Northern Ireland.

Telephone: (0232) 458444

Telex: 747087

Fax: (0232) 705293

Vehicle: Alvis Limited, The Triangle, Walsgrave, Coventry, West Midlands CV2 2SP.

Telephone: (0203) 535455

Telex: 31459

Fax: (0203) 539280

## Shorts Starburst Low Altitude Close Air Defence Self-propelled Missile System

### Development

The Shorts Self-propelled Starburst Close Air Defence Missile System is a private venture version of the manportable Starburst SAM (described in the *Manportable Surface-to-Air Missile Systems* section). The Starburst was developed from the mid-1980s onwards as an advanced unjammable variant of the Javelin manportable low altitude SAM system. The weapon maintains all of the proven characteristics of the parent system's airframe and aiming unit but incorporates the laser optical command guidance technology of the high velocity follow-on, Starstreak, to significantly increase the missile's Single Shot Kill Probability.

The Self-propelled Starburst system is designed for all-weather, 24 hour operations from below armour. It is capable of firing eight missiles sequentially without reloading. Reload weapons can be accommodated in the vehicle, together with an aiming unit and a Lightweight Multiple Launcher (LML) for use in the ground role. For trials and demonstration purposes the system has been mounted on an Alvis Stormer APC chassis but other chassis such as the M113 APC, the AMX-10 APC and the BTR-50 APC can be adapted to the role.

The Self-propelled Starburst system can also be used as a complementary system on the Boeing Avenger, and with integration of the Thomson-CSF Aspic is applicable to a wide range of soft-skinned vehicles and AFVs.

### Description (Alvis Stormer chassis mounting)

The Self-propelled Starburst system comprises a power-operated eight-round launcher with collocated Air Defence Alerting Device (ADAD), power-operated panoramic sight with integral thermal imaging for night engagements, control console with built-in test facility, and a power distribution system.

The launcher unit has eight ready to fire canistered Starburst missiles contained in two panniers mounted on a power-operated, servo-controlled

turret. The launcher is armoured to the same standard as the Stormer to ensure a high degree of survivability on the battlefield. It may be slewed in elevation and azimuth either automatically by the fire control system or manually by the aimer. Reloading of the complete basic load can be carried out in three minutes.

The ADAD unit passively detects target aircraft and helicopters by sensing their natural thermal radiation. Operating on the same band as the sight's thermal imager it provides a 24 hour passive alerting capability.

The panoramic sight system comprises the optical sight, the laser guidance transmitter unit and servo systems. All contained in an armoured housing. The optical sight provides the gunner with low and high magnification fields-of-view for target surveillance and acquisition/tracking respectively. The thermal sight, provides the 24 hour capability, is collimated with the optical sight and gives the aimer a low and high magnification direct image of the target. The laser transmitter unit, collimated to the sight axes, provides the precisely controlled laser information field on the target sightline. As these laser emissions are only transmitted post-launch this virtually eliminates the probability of detection by the target.

The control console, located within the vehicle hull, provides the aimer with direct control of the weapon system and contains all system status indicators, the firing trigger and joystick. It also contains a comprehensive built-in test facility which identifies faults down to Line-Replaceable Unit (LRU) level. The power distribution system monitors the state of a dedicated weapon battery set and controls the voltage and power distributed to all elements of the weapon system.

The Starburst missile consists of a two-stage motor, pre-fragmented blast warhead and dual mode (impact/proximity) capacitance fuze. Twist and steer commands are sent to the forward-mounted steering control surfaces whilst ballistic stability is provided by the rear fins, which also house the two interconnected laser transceiver guidance units. The latter act as the relays between the aiming unit and the missile's forward-positioned electronics and control section.

Each of the transceiver units incorporates a laser receiver, a signal processor and a transmitter in a small cylindrical pod. The reasons for two



*Shorts Self-propelled Starburst System on Alvis Stormer APC*

electrically interconnected pods being fitted are system redundancy and the prevention of any possible screening effects acting upon the guidance signals.

The transmitter is mounted in the nose of the pod and relays the command uplink data to the missile's forward mounted electronics. The optical data signals are detected by small pop-up antennas connected to the control unit, which apart from software changes is essentially unchanged from that used on the Javelin.

The missile canister is a sealed lightweight environmental container which acts as a recoilless launcher tube and is discarded after use. It houses an electrical interface connector to pass firing signals from the aiming unit to the missile. At launch the front cap of the canister is blown off by the gas pressure when the missile gyro is fired.

In combat when the system receives a target indication from the ADAD, the sighting system is slewed automatically onto the target bearing and the aimer alerted to the presence of a target. Alternatively, the target may either be acquired by the aimer using the sight in an automatically controlled sweep mode or by the vehicle commander carrying out his own visual search outside the vehicle.

On acquisition of the target the aimer selects 'Systems On' and tracks the target, using the joystick to place an aiming graticule in his sight onto the target. This tracking enables lead angles to be generated. When the target is within engagement range the aimer presses the trigger and the first-stage motor of the selected missile is ignited, propelling the weapon clear of its launcher-container. After a short period of coasting the second-stage motor ignites, boosting the missile to supersonic speed in less than one second.

Throughout the engagement the aimer's sole task is to maintain the target in the centre of the aiming graticule and the missile is then automatically guided to hit the target. On completion of the engagement the aimer selects another target, and the fire control system automatically allocates the next available missile to be fired.

On reaching the target the missile's warhead is detonated either by impact or the proximity fuzing circuit. If after launch it is realised that the target is in fact a friendly aircraft then the aimer has the facility to command the missile to self-destruct.

A Self-propelled Starburst Trainer Set, powered from the mains supply is available. It consists of an instructor's station and a simulated fighting compartment.

#### **SPECIFICATIONS (missile)**

TYPE	two-stage low altitude
LENGTH	1.394 m
DIAMETER	0.197 m
WEIGHT (missile in canister)	15.2 kg
PROPULSION	two-stage solid propellant
GUIDANCE	beam riding laser
WARHEAD TYPE	2.74 kg HE-fragmentation with contact and proximity fuzing
MAX SPEED	Mach 1 plus
MAX EFFECTIVE RANGE	well in excess of 4000 m
LAUNCHER	8-round turret system on vehicle chassis

**Status:** Ready for production.

**Manufacturer:** Short Brothers PLC, Defence Systems Division, Montgomery Road, Belfast BT6 9HN, Northern Ireland.

Telephone: (0232) 458444

Telex: 747087

Fax: (0232) 705293

## UNITED STATES OF AMERICA

### Boeing Avenger Pedestal-Mounted Stinger Self-Propelled Air Defence System

#### **Development**

In the early 1980s the Defense Systems Division of the Boeing Aerospace Company developed the Avenger air defence system as a private venture. Total time from concept through to delivery to the US Army for trials was only 10 months.

The Avenger consisted of a 4 x 4 High Mobility Multi-Purpose Wheeled Vehicle (HMMWV) with a turret mounted in the rear with eight missiles in the ready to launch position. The turret can also be deployed as a fixed stand-alone unit.

Target acquisition was either by direct vision using the optical sight or through the use of a Forward Looking Infra-red System (FLIR). Mounted either side of the turret are four General Dynamics Stinger SAMs which are identical to those used in the manportable version.

During tests carried out in May 1984 by the US Army at the Yakima Washington Firing Center, three live Stinger rounds were fired at ballistic aerial targets. The first shot was fired from the vehicle moving along an unapproved road about 32 km/h and scored a direct hit. The second shot was at night with the unit stationary and scored a direct hit while for the third shot the vehicle was on the move, in the rain and narrowly missed the target but was scored as a tactical kill as the missile passed within kill range of what would have been an attacking aircraft. The three missiles were fired by different gunners who had never fired a missile before.

In August 1984 the Avenger system was evaluated by the US Army Air Defense Board and during this evaluation 171 of the 178 fixed- and rotary-wing aircraft targets were successfully engaged by the system during the day and night operations.

In 1985 the General Electrical GECAL-50 .50 calibre Gatling Gun was fitted on the Avenger and test fired at the Ethan Allen range in Vermont. The three-barrel GECAL-50 was fired from the Avenger at different burst durations and showed that the turret's gyro-stabilised drive maintains a



*Close up of gunner's position on production Avenger system. Both visual and forward looking infra-red sights are used to detect and track pop-up helicopters, remotely piloted vehicles and low altitude aircraft*

shot pattern of only 1 to 3.5 mils. These trials proved that the gyro-stabilisation system can track targets as easily as when installed on the HMMWV.

In 1986 the US Army issued a request for proposals (RFP) for a Pedestal-Mounted Stinger (PMS), or Line-of-Sight - Rear (LOS-R) as one of the five





*Production Boeing Aerospace Avenger/Pedestal-Mounted Stinger (PMS) system on High Mobility Multi-Purpose Wheeled Vehicle (HMMWV)*

key parts of the Forward Area Air Defense System, an overview of which is given under United States of America in the *Inventory* section. Three teams were subsequently shortlisted and each awarded a \$100 000 contract to supply a single prototype system for US Army trials installed on a HMMWV chassis. The three teams were Boeing Aerospace with the Avenger, General Dynamics/Thomson-CSF/Hughes Electro-Optical Data Systems Group and LVT Aerospace with Crossbow. Extensive trials began early in 1987 at Oragrande Range, New Mexico, after which the Boeing Aerospace Avenger was selected. The extensive trial series included firing, target acquisition and tracking and environmental tests.

In August 1987 the Defense Systems Division of Boeing Aerospace Company, was awarded a contract by the United States Army Missile Command to commence production of the PMS air defence system. The initial contract was for \$16.2 million for the first option buy of 20 systems. The contract has a potential value of \$189 million for 273 fire units over a five year period together with associated logistic support. The second option covering 39 systems was exercised in 1988 (with deliveries to run from July 1989 through to June 1990), the third for 70 firing units in 1989, the fourth 72 firing units in March 1990 and the fifth for 72 firing units in May 1991. A further multi-year production contract for 660 systems over five years is to be approved with the 1991 budget.

First production PMS systems were delivered in November 1988, the system becoming operational with the US Army in 1989, initially with the US Army 3rd Armored Cavalry Regiment at Ft Bliss.

The Avenger was the first shoot-on-the-move air defence weapon to enter production for the US Army. With the award of the production contract, the Avenger programme moved to Huntsville, Alabama, where the system is assembled, tested and delivered to the Army Missile Command at nearby Redstone Arsenal. Boeing's manufacturing facility at Oak Ridge, Tennessee, makes the turret assembly, launcher mechanism and the base assembly that mounts the turret on the HMMWV.

The US Army's total requirement is currently for 1779 systems with the US Marine Corps also looking for additional systems. As the Stinger has been sold to a number of foreign customers, Boeing believe that foreign military sales could eventually bring the total production figure to well over

2000 units. In addition to firing the original Stinger missile model it is also able to launch follow-on models including the Stinger POST.

Main subcontractors to Boeing Aerospace are:  
 General Electric Armament Systems, computer and remote-control unit  
 General Electric Ordnance Systems, electric turret drive as used in the M2 Bradley Infantry Fighting Vehicle  
 CAI, CA-562 optical sight  
 DBA, autotracker  
 FN HERSTAL SA, 12.7 mm M3P machine gun  
 KECO, heater and ventilator  
 Magnavox, forward looking infra-red system  
 Texstar, canopy  
 Texas Instruments, CO<sub>2</sub> laser rangefinder.

Magnavox supply the IR-18 FLIR system to enable Stinger to acquire targets at night and in bad weather. The PMS FLIR is a derivative of the IR-18 sensor developed by Barr & Stroud, UK. The IR-18 FLIR is now produced by Magnavox's Electro-Optical Division at Mahwah, New Jersey.

The system can be installed on other types of chassis, tracked and wheeled and is also fully air-portable. During a demonstration at McChord Air Force Base, Washington, it was shown that three HMMWV or five pallet-mounted systems and their crews could be carried in a C-130 Hercules transport aircraft while six HMMWV or 12 pallet-mounted systems and their crews could be transported in a C-141B Starlifter. The turret module can be carried by a UH-60 while a CH-47 Chinook, CH-46 Sea Knight or CH-53 Sea Stallion can airlift a complete PMS system.

For the US Army PMS system, Stinger missiles are standard, but its design is such that it can accommodate other sensors and other missile systems including wire-guided, infra-red seeking or RBS 70 laser guided.

An example is the Boeing/Shorts Avenger Starstreak programme (described in this section under International). In addition, a mock-up installation of a pod of 36 Hypervelocity Rockets, a current US Army Missile Command (MICOM) project, was installed on the Avenger system.

In addition to the HMMWV and Bv 206 chassis, other potential chassis include the Commercial Utility Cargo Vehicle (CUCV), 2½ ton truck, M548 tracked cargo carrier and M113A3 APC.

### Description

The driver is seated on the left and in addition to having all of the controls required to drive and operate the HMMWV he also has complete inter-communications with the gunner in the turret. All voice (intercom and radio) and system tones (IFF and missile) are provided.

Production Avengers are fitted with AN/PRC77 and AN/VRC47 radios and can accommodate the AN/VRC91 SINCGARS radio system when this is fielded. FAAD C<sup>2</sup>I equipment will also be incorporated as it is fielded with the gunner and driver communicating with each other via the AN/VIC1 intercom system. IFF is provided by the Stinger AN/PPX3B interrogator.

In addition the driver has access to the Remote-Control Unit (RCU) for a redundant control of the turret if required. This is fitted with the same system controls and displays as the turret and enables the Avenger crew to dismount and conduct engagements from remote positions up to 50 m from the fire unit. The RCU can be rotated by 180° to allow a crewman in the passenger seat to operate it and is fitted with training facilities.

Target engagement from the RCU is identical to engagement from within the turret because of hand control switches and indicators on the gunner's console. Components connecting the RCU to the Avenger are control console with FLIR display, drivers combat vehicle crewman helmet, cable connecting CVC helmet and built-in test terminal.

The design of Avenger is modular so that it can accept advances in technology such as the replacement of Stinger by a laser beam rider missile, new sensors, advanced fire control system, Enhanced Position Locator, Reporting System, User System and Hand-held Computer, HVRs or a larger calibre weapon.

The gunner is seated in the electrically powered turret which can be traversed by 360°. If required the complete fire unit can be removed from the HMMWV and used as a stand-alone system. The batteries in the base of the fire unit are interconnected in parallel to the HMMWV's 24 V DC system to provide turret power. The Stinger pods, which are able to accommodate any Stinger model without modification, can be elevated from -10 to +70°. The gunner has a large transparent canopy for all-round observation and to aim the missiles he looks through a sight glass on which he sees the projection of a driven graticule display. The graticule indicates the aiming point of the missile seeker, confirming to the gunner that the missile seeker is locked on the same target he is tracking and planning to engage.

Sensor package mount includes a CAI optical sight, Magnavox FLIR, DBA automatic video tracker (AVT) and a Texas Instrument's CO<sup>2</sup> eye-safe laser rangefinder, thus enabling the system to acquire and track targets under a wide range of operational conditions.

The FLIR with an electrically operated optics cover is mounted on the left launch arm beneath the missile pod. This is a self-contained system operating in the 8-12 µm wavelength region. It has dual field capability and the gunner's foot pedal is used to select the field required. The gunner tracks the target either by direct vision using the optical sight or through the use of the FLIR system for night and poor weather operation.



The PMS can be operated by remote-control with a unit which is carried in the cab of the HMMWV. It can be operated from either the passenger or driver's side of the vehicle and is easily removed to operate the fire unit up to 50 m from the HMMWV. The remote-control unit can also be used when the turret is removed from the HMMWV

The AVT provides an automatic tracking mode. The FLIR video target-to-bore error signals determine the azimuth and elevation repositioning required by the turret drive system in order to maintain turret positioning on the target.

The laser rangefinder is mounted on the left hand launch arm behind the FLIR with target range being displayed on a hand-held display in the turret. Target range is processed by the Avenger control electronics for use in the automated fire permit and fire control algorithms. The Avenger's FCS processes data from the LRF and displays an advisory fire permit symbol in the sight and FLIR display. The fire permit function maximises use of the Stinger's engagement boundaries. The electric turret drive is gyro-stabilised so as to automatically maintain the missile pod aiming direction regardless of the vehicle's movement.

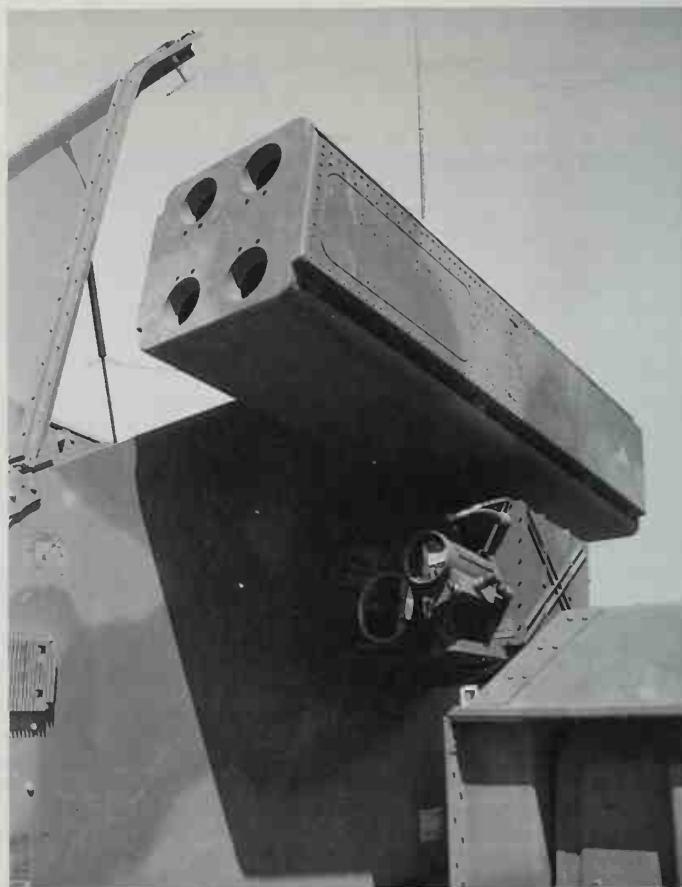
The gunner has a hand controller on which the missile and gun controls are located. In addition, he can transfer tracking control to the automatic tracking systems, one of which uses signals from the uncaged missile seeker and the other data from the FLIR video autotracker, to track the target until the gunner is ready to fire. This allows the gunner to concentrate on target identification. The firing sequence is fully automated and the gunner has only to pull the fire trigger to initiate the launch sequence and immediately select and prepare the next missile for firing.

For self-protection and for coverage of the Stinger dead zone, an M3P 12.7 mm MG with 200 rounds of ready use ammunition is attached to the right hand launch beam as supplementary armament. The M3P is an improved AN-M3 MG with a cyclic rate of fire of 1100 rds/min, 5000 mean rounds between failure, an IR/muzzle blast reducing flash hider and a five mil dispersion. Three hundred rounds of ammunition are carried for ready use with additional rounds in reserve. Mounted either side of the turret is a pod of four Stinger low altitude surface-to-air missiles. Full details of the Stinger missile are given in the *Manportable Surface-to-air missiles* section.

In addition, to the eight missiles in the ready to launch position, an additional eight Stingers are carried in reserve and a standard Stinger grip-stock is also carried for use in the dismounted role. Reloading takes less than four minutes.

### SPECIFICATIONS

CREW	2
CONFIGURATION	4 × 4
COMBAT WEIGHT	3900 kg
WEIGHT OF TURRET MODULE	1134 kg
SYSTEM	
length	4.953 m



Close up of the electric-optic module under the left four-round Stinger launcher of the Avenger Pedestal-Mounted Stinger system (Scott Gourley)



width	2.184 m
height	2.59 m
TURRET MODULE	
length	2.13 m
width	2.159 m
height	1.778 m
GROUND CLEARANCE	0.406 m
TRACK	1.81 m
WHEELBASE	3.3 m
ANGLE OF APPROACH/DEPARTURE	69°/45°
MAX SPEED	105 km/h
RANGE	563 km
FUEL CAPACITY	94 l
MAX GRADIENT	60%
SIDE SLOPE	40%
VERTICAL OBSTACLE	0.56 m
FORDING	0.76 m
ENGINE	V-8 6.2 l, air-cooled diesel
TRANSMISSION	automatic, 3 forward and 1 reverse gears

TRANSFER BOX	2-speed
SUSPENSION (front and rear)	independent, double A-arm, coil spring
STEERING	power assisted
TURNING CIRCLE	14.63 m
BRAKES	
front	hydraulic
rear	disc
TYRES	36 × 12.5 - 16.5
ELECTRICAL SYSTEM	24 V DC
ARMAMENT	2 × 4 Stinger SAMs
	1 × 12.7 mm MG
TURRET TRAVERSE	360°
WEAPON ELEVATION	-10 to +70°

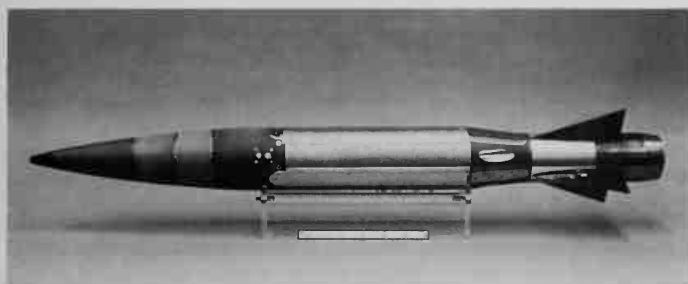
**Status:** In production. In service with the US Army.

**Manufacturer:** Boeing Aerospace, Defense Systems Division, PO Box 1470, Huntsville, Alabama 35807, USA.  
Telephone: 205 461 2803

## Raytheon/Loral Aeronutronic Saber Air Defence Missile System

### Development

The team of Raytheon Missile Systems Division and Loral Aeronutronic (formerly Ford Aerospace Corporation) are working together on the Saber modular missile system as a complementary weapon to the US Army's Avenger Forward Area Air Defense System (qv previous entry in this section) armed with the Stinger.



*Saber surface-to-air missile out of its launch tube*

### Description

Two packs of four ready to fire missiles together with the guidance unit are envisaged to be fitted on an Avenger Air Defense Vehicle.

The Saber missile itself is an eyesafe, countermeasures resistant CO<sub>2</sub> laser beam rider weapon fitted with a 4.09 kg multi-purpose warhead that can be used against both air targets and light armoured vehicles at increased stand-off ranges in practically all types of battlefield obscuration. All the gunner has to do is point the laser beam at any target sighted by himself and which is in direct line-of-sight. The missile is then guided by its aft facing laser beam receiver and the autopilot/sensors pack using the four folding fin flight controls unit.

### SPECIFICATIONS

MISSILE WEIGHT	27.27 kg
DIAMETER	152 mm
LENGTH	1447.8 mm
MAX FLIGHT VELOCITY	in excess of Mach 2

**Status:** Development.

**Manufacturers:** Raytheon, Missile Systems Division, Bedford, Massachusetts 01730, USA.  
Telephone: (617) 274-2168  
Fax: (617) 274-4908

Loral Aeronutronic, Newport Beach, California 96258, USA.  
Telephone: (714) 720 1700  
Telex: 67-8470

## LTV Crossbow Pedestal-Mounted Weapons System

### Development

The Crossbow PMWS was designed as a lightweight pedestal-mounted platform and drive system with on-the-move target acquisition and engagement capabilities.

It is based on a modified 4 × 4 High Mobility Multi-purpose Wheeled Vehicle (HMMWV) with a pedestal weapon/sensor package mounted in the rear. This can be fitted with a wide variety of anti-air/anti-armour weapons in single or combination type configuration according to the user's stated requirements.

The target acquisition and tracking sensor are carried in a compartment located directly above the pedestal post upright on top of the weapons carrier beam. They feed their information directly into the Gunner's Fire Control Console (GFCC) which contains all the elements of the Fire Control System and is used to control the engagement.

Prototype testing of the system has already taken place with firing of 25 mm M242 cannon, 12.7 mm heavy machine guns, Spike rockets and Basic Stinger and Stinger POST surface-to-air missile system configurations.

Future growth potential built into the PMWS includes the possible mechanical or electrical integration of radio frequency interferometers (RFI) and infra-red search sets (IRSS) into the system.

### Description

In the redesigned crew compartment of the HMMWV, the driver remains seated at his normal left-hand position but the gunner takes over the passenger's station on the right. In front of him is the GFCC which is stowed



*LTV Crossbow Pedestal-Mounted Weapons system on HMMWV chassis and showing 12.7 mm MG on right side*

for travel into the space left by relocating the compartment's heater unit to the left wheel well.

In combat the GFCC is extended 279.4 mm into the compartment to a position just in front of the gunner. The unit's integrated video screen displays the target cues, weapon status and firing and aiming reticle symbology data



LTV Crossbow Pedestal-Mounted Weapons system on HMMWV chassis with rocket pod on left side



LTV Crossbow 70 with four Bofors RBS 70 surface-to-air missiles in ready to launch position

while the grip-stock (positioned on the right-hand side of the GFCC) is used to control the weapons platform azimuth and elevation, choose either the TV or FLIR field-of-view scene and select and fire the weapons.

If required the GFCC can be removed from the vehicle for operation at a remote location. The gunner retains full control of all functions independent of the actual pedestal location.

All the gunner has to do wherever he is located is to acquire the target, as an automatic tracking facility maintains the track. This allows him to concentrate on target identification, ranging, weapon selection and optimum firing time. Once he decides these then the superelevation and azimuth lead angles are automatically commanded based on the target range, angular rates and whether a missile, rocket or a gun is being fired.

The sensor compartment contains a FLIR with three fields-of-view, a militarised TV camera (which provides much higher daytime resolution than the FLIR and increases the probability of detecting and identifying targets in high humidity conditions) and a neodymium-yttrium-aluminium-garnet (Nd:YAG) laser rangefinder with a 5 m resolution capability.

The weapons pedestal has a special 'kneeling' stow feature to meet air transport and air drop requirements while still achieving the depressed firing angle required. It is able to traverse a full 360° at up to 60°/s and has elevation/depression limits of +75°/-10°.

The normal weapons configuration is two standard four-round ready to fire missile launcher pods for use with either Basic Stinger or Stinger POST surface-to-air systems. These may be replaced by the Matra Mistral, Bofors RBS 70 or Shorts Starstreak weapons.

If the vehicle is used in the anti-armour role then either a member of the Hughes TOW family or the Rockwell International Hellfire modular missile is used in the missile pods. Only minor modifications to the FCS are required in order to be able to fire any of these missiles. Two spare rounds are stowed within the vehicle hull itself.

Between the electro-optics and the left side missile pod is mounted a 26.4 kg lightweight SACO 12.7 mm calibre machine gun which can fire sabot light armour piercing ammunition to penetrate armoured helicopter airframes. This can be replaced by a 7.62 mm FN HERSTAL SA GPMG if required.

Other armament configurations available include the use of two Oerlikon 20 mm KAA cannon with 250 rpg in place of the missile pod/machine combination, the replacement of the 20 mm guns by 25 mm Mauser or M242 Bushmaster cannon, the replacement of one of the missile pods by a seven-round unguided Spike rocket pod, or the fitting of up to 10 nine-round clips of HYDRA 70 or CRV 7 unguided rockets. In the latter case the sensor compartment is fitted with closable blast doors.

## Crossbow 70

Crossbow 70 is the designation of the Crossbow configuration fitted with the guidance and four-round launcher assembly for the Bofors RBS 70 air defence missile system. Trialled successfully on an LTV HMMWV Crossbow 70 fires the RBS 70 missile (qv RBS 70 entry in *Manportable Surface-to-Air Missile Systems* section for guidance and missile details).

The system can also be used in the self-defence ground role against armoured targets and be fitted with additional rockets or a machine gun.

**Status:** Ready for production. The Crossbow system has been demonstrated on a US Navy ship launching Hellfire missiles and a Swedish Navy ship launching RBS 70 missiles.

**Manufacturer:** LTV, Missiles and Electronics Group, Missiles Division, PO Box 650003, Dallas, Texas 75265-0003, USA.  
Telephone: (214) 266-1824

## Fibre Optic Guided Missile (FOG-M) System

### Development/Description

In December 1988 the US industrial team of Boeing Military Airplane Company, Military Systems Division (58 per cent of designated work) and Hughes Aircraft Company Missile Systems Group (42 per cent of designated work) were awarded the first increment of a \$131.3 million (cost plus incentive fee) contract by the US Army Missile Command (MICOM) for the full-scale development of the Non Line-of-Sight (NLOS) FOG-M component of the US Army's FAADS network.

Previous development details are given in *Jane's Battlefield Air Defence* 1988/89 pages 25-26.

Overall programme costs were expected to exceed \$2 billion if the US Army followed the expected procurement of 285 heavy fire units (based on the US Army/FMC tracked M993 MLRS Carrier with up to 24 missiles aboard for use by Heavy Divisions), 118 light fire units (based on the AM General 4 x 4 M1037 High Mobility Multi-purpose Wheeled Vehicle with six missiles aboard for use by Light Divisions) and 16 550 missile rounds based on the MICOM developed FOG-M weapon. The US Army Budget Director then indicated that research and development would be completed on FOG-M but production was to be shelved until such time as "world conditions dictate" it is needed.

The initial 43 month contract was to have been completed in June 1992 with the team having had to deliver four heavy and five light fire units and 40 missiles. Contractor engineering development and government operational assessments were to take place during Fiscal Year 1990 and 1991.

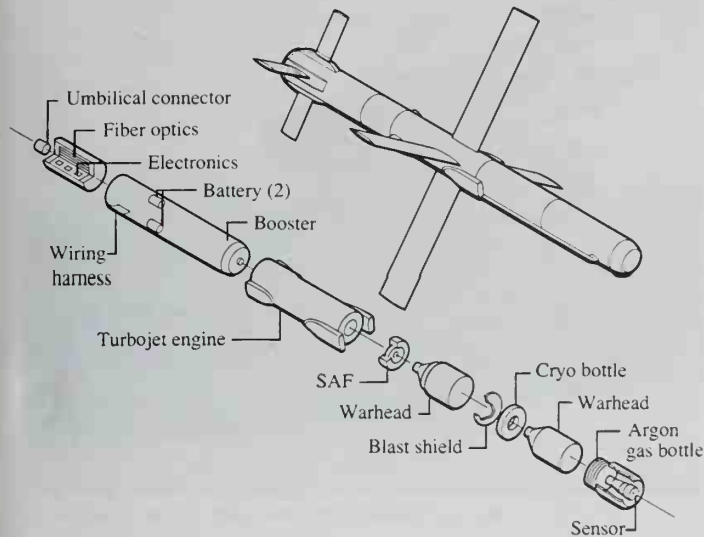
Initial unit operational test and evaluation was scheduled for mid-FY93 with proposed US Army deployment plans calling for one platoon of NLOS weapons being fielded with three platoons of LOS-FH ADATS per air defence battery and three batteries per battalion.

The intended primary role of the FOG-M was to engage and destroy hostile helicopters masked behind battlefield terrain features but it has some secondary anti-armour/ground target capability.

In January 1991 the programme was terminated but in July 1991 the US Army approved a restart programme plan. In order to facilitate this, if funding permits, the operational requirements were reduced. Monies for the system are hoped to be made available in the 1992 and 1993 budgets. The emphasis of the system role is also expected to switch to the anti-armour aspect, with a secondary anti-helicopter mode.

When engaging a helicopter it is launched vertically, flips over 90° and levels off to fly in the general direction of the pre-programmed target position. If it is being used against an enemy ground target the only differences are that it follows a 200 m constant altitude mid-flight course and terminally dives onto the target. In both cases the Hughes day/night/





Major components of the original FOG-M

adverse weather mercury-cadmium-telluride (HgCdTe) nose-mounted passive IR seeker unit transmits target imagery back over the rear-mounted spool wound and employs a hair thin fibre optics data link cable to be computer processed for display on the gunner's video console. The two-way link also transmits the guidance commands to the missile. In the revised programme a simpler TV seeker will be used in place of the IR model.

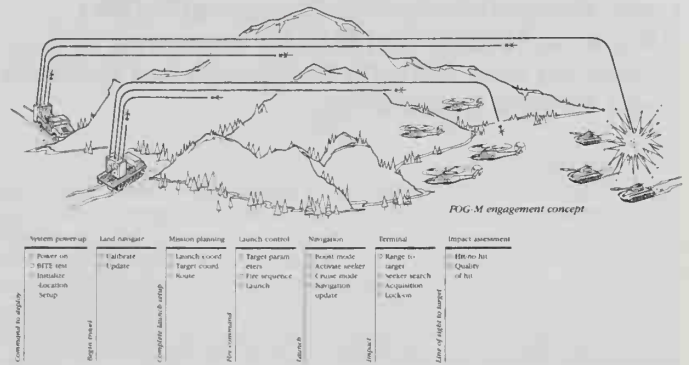
Once the operator in the Fire Unit has attained a visual lock-on he simply centres the cross-hairs on his tactical display onto the target and automatically guides the missile to its destination. If necessary, during the flight he can reject the chosen target and acquire and lock on to another one of higher priority.

The system will also generate a full-colour digital terrain map from a stored database to help the gunner choose the best routes for the initial phase of a missile flight as well as to determine a location for the fire unit. During the mid-course flight phase the missile seeker 'compares' the terrain features it is measuring to the information stored in the database by a system similar in concept to the one fitted to the Pershing II ballistic missile.

The objective system or Block I missile is 2.032 m long, 177.8 mm in diameter and has a maximum span of 1.4424 m. Launch weight is some 43-45 kg. It features wings and control fins in cruciform configuration, a booster motor for launching and a small Williams International WJ-119-2 throttleable axial-flow turbojet Integrated Propulsion Module (IPM) in the



Mock-up of light fire unit version of FOG-M on a HMMWV with launch container in vertical position and FOG-M leaving box



Mission phases of the original Boeing/Hughes FOG-M system

45.5 kg thrust category. The warhead is of two-part type separated by a cryogenic bottle/blast shield. The forward shaped charge is taken from an I-TOW ATGW and is used initially to create a hole in an armoured helicopter airframe or detonate any explosive reactive armour present on an armoured fighting vehicle. This allows the follow-on TOW-2 ATGW shaped charge to penetrate into the target's interior and destroy it.

Maximum range is now required to be 10 000 m for the missile's speed range of 200-400 kts.

As currently configured, FOG-M is mounted in six-round ready to fire container-launcher modules. The launch vehicle contains the bulk of the guidance and control micro-electronics as an integral part of its gunner's station.

**Status:** Programme restart approved by US Army in July 1991. Funding of system for final development and deployment of revised requirement of nearly 350 fire units and 7500 missiles, is being investigated.

**Manufacturers:** Fire Unit station and system integration: Boeing Aerospace, Defence Systems Division, PO Box 1470, Huntsville, Alabama 35807, USA.

Telephone: (205) 859 8357

Missile: Hughes Aircraft Company, Missile Systems Group, 8433 Fallbrook Avenue, Canoga Park, California 91304, USA.

Telephone: (213) 883 2400

Telex: 910 4944 997

Integrated Propulsion Module: Williams International, 2280 West Maple Road, PO Box 200, Walled Lake, Michigan 48088-0200, USA.



Full-scale mock-up of the FOG-M

## Loral Aeronutronic M48 Chaparral/M48A1 Chaparral/M48A2 and M48A3 Improved Chaparral Low Altitude Self-propelled Surface-to-air Missile Systems

### Development

The Chaparral low altitude surface-to-air missile system was initiated with the modification of the US Navy Sidewinder 1C (AIM-9D) air-to-air proportional navigation guidance infra-red homing missile for ground-to-air launch. Study and evaluation of the Chaparral began in 1964 at the Naval Weapons Center, China Lake, California. The following year a development contract was awarded by the US Army Missile Command (MICOM) to Loral Aeronutronic (formerly Ford Aerospace Corporation) (formerly Philco-Ford Corporation), Newport Beach, California. Development and testing were undertaken by Loral Aeronutronic, the Naval Weapons Center and at the White Sands Missile Range in New Mexico. First production missile systems were delivered to the US Army in 1969. Loral Aeronutronic produces the M54 launch and control station, improved missile guidance sections, and test equipment as well as being responsible for overall system integration.

The M48 Chaparral is deployed with the US Army in composite battalions with the M163 Vulcan self-propelled anti-aircraft gun. Each battalion has 24 Chaparral systems (two batteries each with 12 launchers) and 24 M163s (two batteries each with 12 guns). Early warning for the battalion is provided by the Sanders Associates Forward Area Alerting Radar model AN/MPQ-49. In 1991 the US Army stated that the Vulcan air defence systems were being phased out of service and by late 1991 had been phased out of Europe.

The AN/MPQ-49 is a D-band pulse Doppler radar with integral Mk XII IFF set. Detection range on a 0.2 m radar cross-section target is from 1000 to 15 000 m. The system weighs some 1364 kg and is housed in an S-250 shelter. Information is passed to the air defence team(s) on the launcher units by a one-way digital data FM radio link with a maximum range of 15 000 m. The data is displayed at the weapon site by the Digital Target Alert Data Display Set (TADDS). This warns the site crew of an approaching aircraft, provides tentative identification and gives the approximate range and azimuth. The link can handle up to 49 friendly and 49 unknown (hostile) targets.

The Chaparral is one of the US Army air defence assets being replaced in the active force component by the FAAD systems. In 1984 the US Army Air Defence Artillery School presented a plan to transfer some of the Divisional Chaparral systems to the Army National Guard.

The first battalion, 1-200th ADA New Mexico ANG, was converted in late 1984 and also became the first Corps Chaparral battalion in the US Army structure attaining operational status in this role in early 1989 with the M48A1 system (conversion to the M48A3 version took place in 1990). By the end of 1989 the New Mexico ANG had four more battalions: 2-200th ADA (M48A1 converted to M48A3 in 1990), 3-200th ADA (M48A2 version), 4-200th (M48A1 version converted to M48A3 in 1990) and 6-200th ADA. Additional ANG Chaparral Corps level battalion units include the 1-265th ADA and the 3-265th ADA of the Florida ANG. The latter will only receive its last two batteries of Chaparral fire units when the 5-5th ADA in Korea is re-equipped with the Pedestal-Mounted Stinger. In FY90 the 1-233rd ADA battalion activated as a Corps Chaparral unit with the Arkansas ANG.

In the regular US Army Chaparral fire units are also being withdrawn from the Heavy Division air defence role and reassigned to Corps level battalions. The first three units to be formed in this way were the 1-2nd ADA



*Towed Chaparral SAM system - US Army has taken delivery of 13*

XVIII Airborne Corps battalion (M48A3 version), 2-2nd ADA battalion (M48A3 version) and the 3-3rd ADA battalion (M48A2E1 version).

Each of the ANG and regular Army Chaparral battalions mentioned above have three batteries each with 12 Chaparral fire units.

A towed self-contained trailer system, designated M85, uses the same launch and control system as the self-propelled M48. The M85 weighs 5250 kg empty and carries four ready to fire missiles and four stowed reloads, when in the operational configuration. In early 1984 a \$10.6 million contract was placed for 13 systems of this type for use by the 9th Infantry Division on rapid-deployment type exercises overseas.

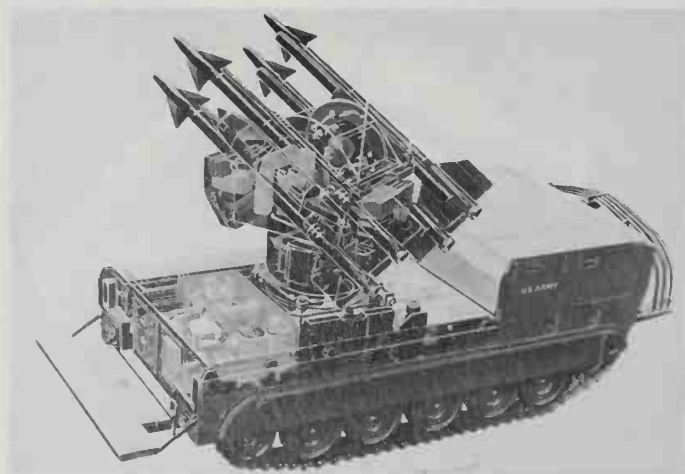
A version known as Sea Chaparral has also been developed by Loral Aeronutronic using a modified M54 launcher and is in use with the Taiwanese Navy aboard its larger warships.

By 1 September 1990 714 Chaparral systems had been built, of which 596 had been purchased by the US Army (which has a total procurement objective of 632 systems). Chaparral saw combat use with the Israeli Army on the Golan Heights when it shot down a MiG-17 on 16th May 1974 and in the 1982 Israeli invasion of Lebanon.

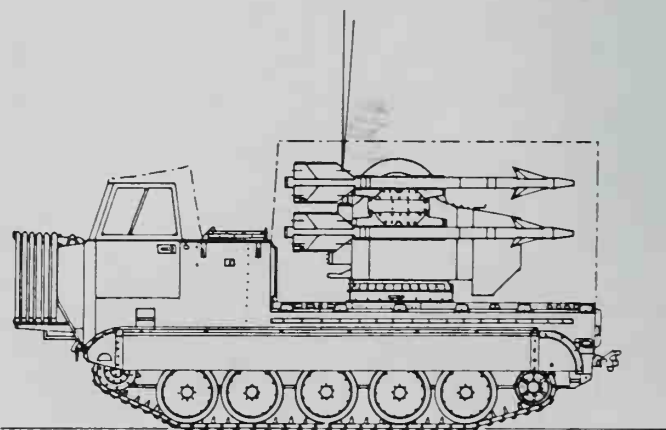
Two battalions of Chaparral were deployed to the Gulf for the Desert Shield/Desert Storm operations.

In 1983 the Pentagon announced a letter of offer to Egypt for the sale of 25 M48A2 Improved Chaparral self-propelled air defence systems, MIM-72F missiles and seven modified M577A2 command post vehicles at a total cost of \$112 million. This offer was accepted the following year and first deliveries were made early in 1988. Associated with the Egyptian sale, Sanders Associates provided seven of its TRACKSTAR (Tracked Search and Target Acquisition Radar Systems) mounted on top of the modified FMC M577A2 tracked command post vehicle chassis.

In 1986 Portugal ordered five Chaparral systems, 28 MIM-72F missiles, two AN/MPQ-54 Forward Area Alerting Radars (FAARS), spares and support equipment with a total value of \$45 million. These have now been delivered.



*Chaparral surface-to-air missile system showing main components, bows stowed at front of vehicle and anti-blast shield positioned over cab*



*Chaparral surface-to-air missile system in travelling order without bows or tarpaulin cover in position*





*Chaparral of the Israel Defence Forces in its deployed configuration*

In 1986 Taiwan ordered 52 Chaparral fire units and associated spare parts valued at \$29 million with final deliveries made during 1989.

### Description

A standard configuration Chaparral fire unit consists of two main elements, a tracked carrier and the M54 missile launch station. The carrier is designated the M730 and is based on the M548 tracked cargo carrier which in turn uses components of the M113A1 armoured personnel carrier.

The crew of four is driven by US Army human consideration factors concerning the reloading of the missiles. The four comprise a squad leader (who makes the target selections, identifications and issues the fire orders), senior gunner (who operates the launch and control station and is system second-in-command), vehicle driver (who can also function as an observer and/or radio operator) and one backup gunner (who primarily acts as target observer). This allows 24 hour system operation/readiness.

The M730 has the engine and crew compartment at the front of the vehicle and supports the missile launch station behind the engine compartment. The crew compartment is equipped with front, sides, rear and top, which are removed before the missiles are launched. The vehicle is supported by a torsion bar suspension and a drive system that consists of tracks running on five dual rubber-tyred road wheels on each side with the drive sprockets at the front and idlers at the rear. There are no track return rollers. The vehicle is fitted with infra-red driving lights. When the flotation screen is erected around the rear of the hull the vehicle is fully amphibious, being propelled in the water by its tracks.

In 1982 a Product Improvement programme was approved to modify the M730 missile carrier for use with the RISE power train developed for the M113A1E1 APC. The M730 was in particular need of improvement to its drive train reliability and performance because of the Chaparral system combat weight. The first conversion to this standard took place in 1987 with the whole fleet of 596 modified by 1989. The vehicle is then known as the M730A2.

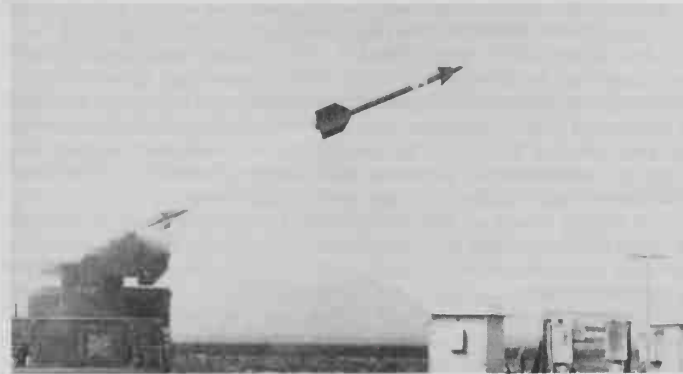
The launch and control station (designated the M54), consists of the base structure and turret. The base structure provides mechanical support and contains essential auxiliary equipment including the engine/generator electrical power source, and storage for missiles, crew equipment and tools. The senior gunner's compartment, which is inside the turret, has filtered and conditioned air and an adjustable seat. All US Army systems are being fitted with NBC protection equipment. The missile control electronics operate in conjunction with the control panel switches and indicators to control the activation of the system, missile selection and sequencing, missile launch sequencing and test functions. Each missile launch station contains an IFF subsystem.

The Chaparral system uses a hydraulic turret drive that responds to rate commands from the gunner's hand control. The drive subsystem allows unrestricted movement in azimuth and movement in elevation from  $-9^\circ$  to  $+90^\circ$ . The air compressor is part of the missile air supply subsystem which supplies highly compressed air for the cooling infra-red detectors. The subsystem accepts outside air, compresses, filters and purifies it, and distributes it to each launcher assembly and the FLIR assembly.

The main power unit, a petrol (M48 and M48A1) or diesel (M48A2 and M48A3) powered engine/generator set with associated power supply, provides the regulated power needed for all functions. If the power unit malfunctions the operator can continue for a limited period using the onboard storage batteries.

The missile itself is an in-line cruciform type with two pairs of canard control surfaces at the forward end and two pairs of fixed wings at the rear. One pair of the rear wings is provided with rollerons to reduce roll rate. The missile is attached to the launch rail by hangers fixed to the rocket motor case. Four missiles are carried ready to launch and a further eight are carried in reserve.

The original missile, designated the MIM-72A, has a launch weight of 86.9 kg, is 2.91 m long and has a diameter of 127 mm, a wingspan of



*Chaparral missile being launched during trials at White Sands Missile Range (US Army)*

0.715 m and is fitted with an 11.2 kg high explosive warhead. Between 1970 and 1974 an improved all-aspect missile called the MIM-72C was developed, which entered service in July 1978. It weighs 85.7 kg, the other dimensions remain the same, and includes an M817 radar proximity fuze developed by Harry Diamond Laboratories, a 12.6 kg M250 HE blast-fragmentation warhead developed by Picatinny Arsenal and an AN/DAW-1B all-aspect IR seeker with IRCCM developed by Loral Aeronutronic (formerly Ford Aerospace Corporation). Effective launch range is increased to over 9000 m. Later versions of this missile with smokeless motor are designated the MIM-72E. Non-CCM versions (AN/DAW-1 seekers) are designated MIM-72F and MIM-72H. All versions are powered by a single-stage solid propellant rocket motor. The battlefield signature of the system has been reduced by the adoption of the M121 smokeless motor for the later missiles.

To provide a night and bad-weather capability and to improve daylight performance in smoke and haze the US Army has retrofitted launchers with forward-looking infra-red (FLIR) thermal-imaging device, with autotrack features. The FLIR contains 180 mercury-cadmium-telluride 8-12  $\mu\text{m}$  wavelength elements, has an  $18 \times 20^\circ$  wide field-of-view, and a  $2 \times 2.7^\circ$  narrow field-of-view. It can operate in either a wide or narrow field-of-view to optimise the infra-red detection capability of the receiver and improve the thermal image for the gunner. The optics on the receiver magnify the image and the infra-red target video obtained is presented on the video display located in the mount. At the moment of missile launch a small protective cover will briefly close over the FLIR optics to protect the sensitive optical elements. The system also contains a lightweight Mk XII IFF subsystem for target friend/foe identification.

In addition a new 30 hp diesel engine has been retrofitted to replace the 10 hp petrol engine used previously. This both increases the power available and introduce fuel commonality with the M730. With the RISE power train and forward looking infra-red the designation changes to M48A3. With just the forward looking infra-red it is M48A2 Improved Chaparral.

Before the system can be used the crew leaves the cab, folds down the windscreen, removes the cab cover and folds a six-piece hinged blast-shield over the cab and engine compartment. An additional fixed blast-shield protects the back of the engine compartment. The six bows and tarpaulin cover are then removed from the launcher area and the bows are stowed on the front of the hull. The launcher is then electromechanically raised into the firing position.

A typical daylight target engagement takes place as follows. Early warning is provided either by the AN/MPQ-49 Forward Area Alerting Radar or by a visual sighting. Once the gunner detects the target he moves the turret to acquire and maintain the aircraft in the centre of his sight or FLIR field-of-view. The turret can be traversed by  $360^\circ$  and the launch rails have an elevation of  $+90^\circ$  and a depression of  $-9^\circ$ . As the gunner tracks the target, an audio tone in his headset notifies him when the target is within infra-red sensing range.

The gunner then launches a fire-and-forget missile which operates under its own internal power. Proportional navigation guidance commands are generated from seeker tracking rates and used to control the missile flight path. Proximity fuzing assures that the warhead will detonate even without a direct hit. The fire-and-forget capability allows the gunner to begin to search for and attack another target immediately. The rate of fire of the basic system is four missiles per minute with a full reload time of five minutes. The single shot kill probability was assessed at 0.5 against targets with velocities between 0 to 550 knots with the basic missile but this has been substantially improved with later missile versions. The Chaparral surface-to-air missile has maximum effective range limits from 500 m to beyond 12 000 m and effective altitude limits of less than 15 m to greater than 3000 m. The missile is armed after 180-340 m of flight.

A new guidance section called the Rosette Scan Seeker (RSS) and designated AN/DAW-2 was developed for the Chaparral missile under a contract placed by MICOM with Loral Aeronutronic (formerly Ford Aerospace Corporation). Development started in 1982 and the seeker was type classified

in August 1987. Missiles fitted with the RSS guidance section are known by the designation MIM-72G. The Loral Aeronutronic Corporation has been awarded a production contract for 441 RSS guidance sections plus depot test equipment for delivery in 1990-92. Within the contract, options exist for 422 additional RSS units. Hughes Aircraft Company Tuscon was awarded a contract as a second source producer of 721 RSS guidance sections for delivery between 1990-92. This second source production contract also contains options for an additional 422 sections, these have now been exercised to give Hughes contracts totalling \$52 million.

The RSS is based on software that can be reprogrammed to take into account evolving threats such as different heat signatures, flares and other infra-red countermeasures. It is electronically reprogrammed through the umbilical connector.

According to the manufacturer, Chaparral has now achieved virtual immunity to all types of infra-red countermeasures. Increased engagements and earlier launches are achieved by Chaparral with the Rosette Scan Seeker. Target acquisitions at 50 per cent longer range than the current guidance have been demonstrated. Flight tests including contact hits on a helicopter target beyond 8000 m launch range and on fixed-wing targets beyond 12 000 m have been successfully conducted.

### Egyptian TRACKSTAR Radar

Supporting the Chaparral Air Defence System for the Egyptian Army, the TRACKSTAR radar system is a self-contained 360° D-band 60 km range AN/MPQ-49 derivative integrated radar/command and control (C<sup>2</sup>) system. It is used by the Egyptian army with its Chaparral fire units and automatically broadcasts cueing, fire distribution and IFF data via its VHF radio or hard-wire data links to Integrated Weapon Display (IWD) operator control and processor units (total weight 8.2 kg) that are mounted in the Chaparral fire units.

The target cueing information is transmitted in terms of UTM co-ordinates and converted and orientated to each fire unit by the IWD processor. This has a target/display capacity for up to 32 targets and permits the input of operational parameters and selection of tactical modes. Command messages from the TRACKSTAR commander can also be added to the

target information flow over the data link and may be addressed to any or all the Chaparral fire units as required.

With IWD, the Chaparral gunner of the fire unit simply positions the boresight symbol over the designated target symbol, thereby pre-positioning the missile launch station to ensure that the target will appear in his field-of-view. This flexibility allows fire distribution tasks to be centrally controlled or delegated to gunners according to standard operating procedures.

Automatic netting of multiple TRACKSTAR systems is used to help uncover terrain masked targets and provide additional advanced warning and cueing information.

### Future Chaparral Variants

With cancellation or delays of other air defence systems Loral Aeronutronic is looking at advanced Chaparral systems to meet future short-range air defence requirements. One such system is based on an FMC FVS chassis for improved mobility, a reduced crew of three in an armoured cab, improved vehicle protection and a stabilised optical sight with the forward looking infra-red display integrated with a radar display from a separate unit allows the Improved Chaparral launcher assembly to shoot on-the-move and reduce march order and emplacement times to effectively zero. Another is the Chaparral Block VII system, the most recent concept under study and described in the next entry.

The introduction of dual spectral sensors, with infra-red and radio-frequency data fusion, expands the operational capability of the Improved Chaparral system to produce the Chaparral 2000. The new development by Loral Aeronutronic incorporates multi-mode guidance systems and tail controls in the Chaparral missile to increase the range and firepower while retaining the passive characteristics. The missile is known as Chaparral 2000 and it will have a range in excess of 15 000 m. The supporting Chaparral 2000 launcher would be an upgraded Improved Chaparral vehicle fitted with an infra-red search and track set and a passive radio-frequency sensor. Integration of the Chaparral 2000 launcher with the MLRS carrier vehicle reduces the crew requirement to two. Alternatively a Chaparral 2000 system with 10 ready to fire container-launchers on a derivative of the Standard Manufacturing Company's hydrostatic vehicle with a mast-mounted surveillance radar and interferometer (to detect electronic emissions from aircraft) is being suggested for the US Army's Light Infantry Divisions. It would only weigh about 6818 kg and be easily air-transportable.

### SPECIFICATIONS

CREW	4
COMBAT WEIGHT	13 024 kg
UNLOADED WEIGHT	
(without launcher and missiles)	6425 kg
POWER-TO-WEIGHT RATIO	
Basic	16.1 hp/t
RISE	21.1 hp/t
GROUND PRESSURE	0.61 kg/cm <sup>2</sup>
LENGTH	6.06 m
WIDTH	2.69 m
reduced	2.54 m
HEIGHT (with bows and tarpaulin cover)	2.68 m
GROUND CLEARANCE	0.4 m
TRACK	2.159 m
TRACK WIDTH	381 mm
LENGTH OF TRACK ON GROUND	2.82 m
MAX SPEED	
road, forwards	67.2 km/h
on 10% gradient	20.1 km/h
water	5.5 km/h



Egypt is the only user of the Sanders Associates TRACKSTAR integrated radar/command and control system based on an FMC M577A2 tracked chassis



Chaparral self-propelled air defence system used by Taiwan (DTM)



FUEL CAPACITY	401 l
MAX RANGE	504 km
FORDING (with preparation)	amphibious
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	0.62 m
TRENCH	1.68 m
ENGINE	
Basic	Detroit Diesel model 6V-53 6-cylinder water-cooled diesel developing 210 bhp at 2800 rpm
RISE	Detroit Diesel model 6V53-T 6-cylinder water-cooled diesel developing 275 bhp at 2800 rpm
TRANSMISSION	
Basic	Allison TX-100 consisting of 3-speed gearbox and 2-stage torque converter giving 6 forward and 2 reverse gears
RISE	Allison X-200-4 consisting of a hydrokinetic automatic gearbox with 4 forward and 1 reverse gear
SUSPENSION	torsion bar
ELECTRICAL SYSTEM	28 V

ARMAMENT	launcher with 4 Chaparral missiles (8 reserve missiles carried)
ARMOUR	none

**Status:** In production in both basic and Improved Chaparral configurations.  
In service with the following countries:

Country	Quantity	User	Comment
Egypt	25	army	M48A2 delivered 1988
Israel	52	air force	
Morocco	37	army	delivered 1987
Portugal	5	army	
Taiwan	52	army	
Tunisia	26	army	
USA	523	army	

**Manufacturers:** Loral Aeronutronic, Newport Beach, California 92658, USA (chassis is supplied by FMC Corporation of San Jose, California).  
Telephone: (714) 720 1700  
Telex: 67-8470

**TRACKSTAR and Integrated Weapon Display (IWD):** Sanders Associates Inc (a Lockheed company), Defence and Information Systems Division, Nashua, New Hampshire, NH 03061-2035, USA.  
Telephone: (603) 9522  
Telex: 94-3430

## Loral Aeronutronic Chaparral Block VII Low Altitude Surface-to-air Missile System

### Development/Description

As part of its continuing programme to explore technologies and concepts that can be incorporated into the Chaparral system to extend its capabilities so that it retains high lethality in modern wartime scenarios, Loral Aeronutronic is studying the Chaparral Block VII concept. The Block VII designation recognises that the Chaparral systems currently deployed by the US Army have been modernised through the Block VI upgrades.



The additional Block VII features can be summarised as:

- Missile guidance - the MIM-72G missile has been augmented with a second guidance mode to address stand-off helicopters in heavy clutter at ranges beyond 6000 m. The second mode is a command to line-of-sight (CLOS) system that uses the FLIR to track the target and guide the missile. Mid-course handover to the main fire-and-forget seeker would be expected in most engagements.
- Missile launcher - the launcher unit has been redesigned as an unmanned installation with additional launch rails added to give a total of six ready to fire MIM-72 missiles. A rangefinder device has also been added to ensure that targets to be engaged with the CLOS guidance system are within effective missile range.
- Vehicle - the current M730A2 vehicle can be modernised by stretching the chassis by approximately 0.66 m and adding a sixth road wheel. This in turn allows for an armoured crew cab to be fitted that features over-pressure NBC protection for the crew. The gunner will be removed from the turret and relocated into the crew cab. This redesign provides for enhanced mobility, crew protection and C-130 Hercules transportability.
- Load assist - a simple jib crane has been added along with launch rail modifications to simplify the missile reload function. This allows the crew total to be reduced to three from the current four.
- Grenade launcher - a self-defence grenade launcher system has been added to the vehicle for use with smoke and fragmentation grenades.

**Status:** Concept phase.

**Manufacturer:** Loral Aeronutronic, Newport Beach, California 92658, USA.  
Telephone: (714) 720 1700  
Telex: 67-8470

*Model of the proposed Loral Aeronutronic Chaparral Block VII low altitude SAM system based on a stretched M548 series chassis*

## Loral Aeronutronic Corps Surface-to-air Missile System

### Development/Description

The Loral Aeronutronic has proposed a version of the Chaparral SAM, known as the Corps Surface-to-air Missile System, to meet increased firepower and battlefield survivability criteria. It is designed to operate as a stand-alone system and will have a fire-on-the-move capability.

The system is based on the tracked M987 chassis which is currently in production for the Multiple Launch Rocket System (MLRS) programme and under consideration for a number of other applications.

The crew would be seated in a fully enclosed armoured cab at the front of the vehicle, which would also be fitted with an NBC system. Within the cab is an advanced autonomous fire control system processor and displays console suite capable of taking inputs from the command and control net, onboard vehicle sensors and the built-in track-while-scan facility.

To the rear of the cab is an unmanned launcher assembly system with eight launch canisters for Chaparral SAMs in the ready to fire position. These would be of an improved MIM-72G missile type with the AN/DAW-2 Rosette Scan Seeker (RSS) guidance section, already in production for the US Army. The proposed 15 000 m range plus Chaparral 2000 missile with dual passive RF/infra-red guidance, reprogrammable guidance, low drag airframe and improved tail controls could also be employed.

The onboard pedestal-mounted sensor pack is for all-weather day/night operation and includes an infra-red search and track (IRST) unit, an acoustic sensor, a passive IBM APR-48 Interferometer NCTR (non co-operative target recognition) sensor and a low-probability of intercept range-only radar.

### Variants

Further proposals by Loral Aeronutronic to enhance the Corps SAM system include the use of an M987 chassis version carrying two six-round packs for vertically launched missiles, an IRST and a pod-mounted fire control/command system. A further two six-round missile packs could be attached



*Scale model of the private venture Loral Aeronutronic Corporation Surface-to-Air Missile System*

to double the number of ready to fire rounds, but these would have to be removed before the fire unit could be airlifted in a C-141 type aircraft.

Additional enhancements to the Chaparral II missile could be made by adopting either a new rocket motor, based on a high energy solid propellant fuel (to give a range of 25 000 m) or a UTC Chemical Systems Division ram-rocket solid propellant rocket unit (to give a range of 40 000 m).

**Status:** Concept phase.

**Manufacturer:** Loral Aeronutronic, Newport Beach, California 92658, USA.  
Telephone: (714) 720 1700  
Telex: 67-8470



# Towed Anti-Aircraft Guns

## BRAZIL

### Modernised 12.7 mm Anti-aircraft Machine Gun M55

#### Development/Description

Brazil was one of many countries to receive 12.7 mm Quad M55 machine gun mounts from the USA during the Military Assistance Program of the 1950s and 1960s. The Brazilian Armed Forces still use these mounts, but for some time they have had difficulty in obtaining spares and various attempts have been made to modernise them. During the early 1970s the Instituto de Pesquisa e Desenvolvimento (IPD — Research and Development) in Rio de Janeiro carried out a development programme to produce spares locally, but this did not prove feasible, nor did a 1979 project to substitute a hydraulic-powered drive. In mid-1980 it was decided to produce an entirely new electromechanical drive system using some existing parts, but replacing the electrical components with a commercially available petrol engine and accessories.

Operational testing of the new system took place at the Campo de Provas da Marambaia (CPrM — Marambaia Proving Grounds) between September 1980 and July 1981 when production certification was granted. The trials were carried out under the auspices of the Centro Tecnológico do Exército (CTEx — Army Technological Centre) in Rio de Janeiro.

This modernisation involves the overhaul of all mechanical and electrical components and the new items added include a five or six hp Montgomery M-226 or M-252 petrol engine with a five litre fuel tank (fuel consumption is 2.33 l/hr), a standard 12 V 36 A battery, a 14 V 36 A Wapsa alternator, a 12 V 36 A Wapsa power regulator, a 12 V Bosch starter motor, a Fiat 147 ring gear and a V-belt transmission. The modernised mount can now be powered permanently and the traverse and elevation velocities are now over 90°/s (originally they were at best 60°/s). In the case of a petrol engine failure, the mount can be operated using the starter motor for three minutes.

#### Variants

A version armed with two 20 mm Hispano-Suiza HS 404 cannon was completed in 1984.



Modernised M55 quad 12.7 mm anti-aircraft gun system of Brazilian Army (Mario Roberto V Carneiro)

Early in 1984 the prototype of a self-propelled anti-aircraft gun system was tested in Brazil. This consists of an X1A light tank chassis fitted with the modernised M55 12.7 mm anti-aircraft machine gun. As of late 1991 this version had not entered production for the Brazilian Army.

**Status:** Production as required for Brazilian Army and export.

**Manufacturer:** LYSAM — Indústria e Comércio de Máquinas e Equipamentos Limitada, Rua Marques de Oliveira, 53—Ramos, 21031 Rio de Janeiro, Brazil.

## CHILE

### FAMIL FAM-2M Twin 20 mm Light Anti-aircraft Gun

#### Development/Description

The first 20 mm anti-aircraft guns in the FAMIL series were produced under the name Sogeco; FAMIL is now a subsidiary of Sogeco. The first guns in the series used Hispano-Suiza HSS 820 cannon taken from redundant Vampire T.11 aircraft, but the latest guns in the series use Oerlikon KAD B16 and B17 cannon with a muzzle velocity of 1040 m/s. These guns are mainly used for airfield defence, but they can also be used against ground targets.

The carriages on all the guns produced so far are similar and are supported in the firing position on four folding outriggers. For transport, the

gun is carried on a removable twin-wheeled yoke carriage. Power for the mounting is supplied by a small petrol engine on the right-hand side of the carriage. The engine drives a hydraulic system which is controlled by the gunner using a single joystick control. The latest models also have a 24 V electrical system supplied from two 12 V batteries for the sight electrics. A shield is fitted.

Early models use a simple cartwheel sight, but the latest models have a Ferranti gyroscopic reflector sight that can be used together with a Ferranti target injection training system. In service now is a central control system that controls up to four guns from a single control box mounting a single joystick to act as a fire director system for a battery. A version using centralised radar control is under development.

The Hispano-Suiza 820 cannon versions use drum magazines each holding 120 rounds of ready use ammunition. The Oerlikon KAD cannon have box magazines each holding belts of 200 rounds.

#### SPECIFICATIONS (Oerlikon KAD cannon version)

CALIBRE	20 mm
OPERATION	gas, automatic
CARRIAGE	2-wheel with 4 outriggers
SHIELD	yes
WEIGHT	
in action	approx 1700 kg
in firing position	1250 kg
of transport carriage	350 kg
of ammunition	68 kg
one cannon	68 kg
RATE OF FIRE (cyclic)	2100 rpm
FEED	2 × 200-round belts in boxes
EFFECTIVE RANGE	1500 m

**Status:** In production. In service with the Chilean Air Force.

**Manufacturer:** FAMIL SA, Mac-Iver 125 - 6° Piso, Santiago, Chile.



FAMIL FAM-2M twin Oerlikon-Contraves KAD 20 mm anti-aircraft gun with Hispano-Suiza 820 cannon (T J Gander)

## Twin 12.7 mm Anti-aircraft Gun

### Development/Description

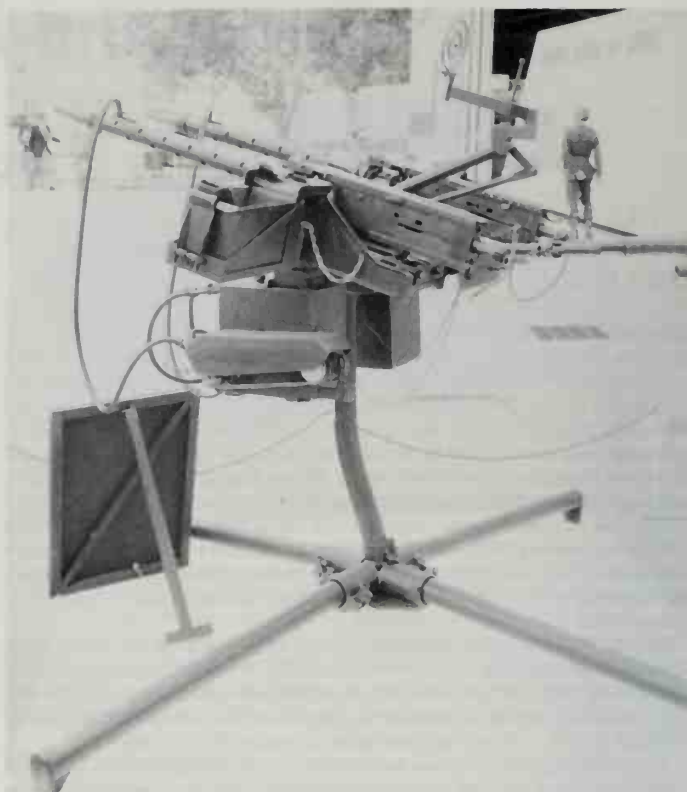
This twin 12.7 mm (0.50) Browning M2 anti-aircraft gun uses water-cooled barrels converted from the normal air-cooled barrels. The water-cooling barrel liners are contained in perforated jackets around each barrel and the barrels are fitted with new multi-baffle muzzle brakes. Water is circulated via flexible hoses through the barrel liners by a single water pump, powered by two 12 V batteries. The complete system is mounted on a modified M63 pedestal mounting. A cartwheel sight is provided.

The 12.7 mm water-cooled Browning M2 machine guns are converted from aircraft guns and the receiver, mechanism and ammunition feed remain unchanged.

Indications are that the modifications have been introduced by the Chilean Air Force.

**Status:** Production complete. In service with the Chilean Air Force.

*Chilean twin 12.7 mm water-cooled anti-aircraft gun showing water pump for circulating water through barrel cooling liners; two 12 V batteries used to power water pump can be seen either side of central pedestal tube (T J Gander)*



## CHINA, PEOPLE'S REPUBLIC

### NORINCO 12.7 mm Anti-aircraft Machine Gun Type 54

#### Development

The NORINCO 12.7 mm anti-aircraft machine gun Type 54 is essentially the Soviet 12.7 mm Degtyarev Model 38/46 (DShKM) heavy machine gun made in China under the designation of the Type 54.

It has been designed to engage both air and ground targets. In the first application the tripod is almost vertical, while in the second application it is almost horizontal. The Type 54 is also used on a number of Chinese armoured fighting vehicles as an air defence weapon.

#### Description

Ammunition is fed from the left in boxes of 70 rounds and two types of 12.7 mm × 108 ammunition can be fired; armour-piercing incendiary and armour-piercing incendiary tracer, both with a muzzle velocity of 820 m/s. The round will penetrate 10 mm of armour at a range of 800 m.

The foresight is a pillar which slides up and down, while the rear sight has twin vertical pillars with a U-backsight between them. In addition there is a special anti-aircraft sight which requires two men to use it to its best advantage.

#### Variants

The Type 54-1 is an improved version of the Type 54 weapon and weighs 45 kg, with elevation in the air defence role being from  $-26^{\circ}$  to  $+72^{\circ}$ .

#### SPECIFICATIONS

CALIBRE	12.7 mm
PRACTICAL RATE OF FIRE	80 rpm
OPERATION	gas, automatic
METHOD OF LOCKING	projecting lugs
FEED	belt
WEIGHT OF GUN	35.7 kg
WEIGHT OF BARREL	12.7 kg
EFFECTIVE RANGE AGAINST AIR TARGETS	1600 m
EFFECTIVE RANGE AGAINST GROUND TARGETS	1500 m
ELEVATION IN AIR DEFENCE ROLE	$-34^{\circ}$ to $+78^{\circ}$
TRAVERSE IN AIR DEFENCE ROLE	$360^{\circ}$
TRAVERSE IN GROUND DEFENCE ROLE	$120^{\circ}$

**Status:** In production. In service with Chinese Army and other countries.

**Manufacturer:** China North Industries Corporation, 7A Yuetan Nanjie, PO Box 2137 Beijing, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3471, 7570  
Telex: 22339 CNIN CN



*NORINCO Type 54 anti-aircraft machine gun being used in air defence role*



## NORINCO 12.7 mm Type 77 Anti-aircraft Machine Gun

### Development

The NORINCO 12.7 mm Type 77 anti-aircraft machine gun has been designed to engage both air and ground targets. In the first application the tripod is almost vertical, while in the second it is almost horizontal.



*NORINCO Type 77 anti-aircraft machine gun in air defence role*

### Description

The weapon appears to be recoil-operated and has both ground and anti-aircraft sights. A distinctive pepperpot muzzle brake is provided.

Ammunition is fed from the left in boxes of 60 rounds and two basic types of 12.7 mm × 107 ammunition can be fired; armour-piercing incendiary and armour-piercing incendiary tracer, both with a muzzle velocity of 800 m/s.

### SPECIFICATIONS

CALIBRE	12.7 mm
RATE OF FIRE (cyclic)	650 to 750 rpm
WEIGHT (with empty ammunition box)	56.1 kg
LENGTH IN GROUND ROLE	2.15 m
WIDTH IN GROUND ROLE	1.3 m
AXIS OF FIRE	
ground role	0.36 m
air defence role	1.3 m
EFFECTIVE RANGE	
air targets	1600 m
ground targets	1500 m
ELEVATION IN AIR DEFENCE ROLE	-15 to +80°
TRAVERSE	
air defence role	360°
ground role	120°

**Status:** In production. In service with Chinese Army and other countries.

**Manufacturer:** China North Industries Corporation, 7A Yuetan Nanjie, PO Box 2137 Beijing, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3471, 7570  
Telex: 22339 CNIN CN

## NORINCO 12.7 mm Type W-85 Anti-aircraft Machine Gun

### Development

The NORINCO 12.7 mm Type W-85 anti-aircraft machine gun has been developed as a multi-purpose weapon for use at the battalion level to engage both air and ground targets. In the first application the tripod is almost vertical, while in the second it is almost horizontal. Compared with the older Type 54 12.7 mm anti-aircraft machine gun, it is some 58 per cent lighter and can be easily disassembled into three parts, the heaviest of which does not exceed 20 kg; these are the weapon, mount and ammunition box.

### Description

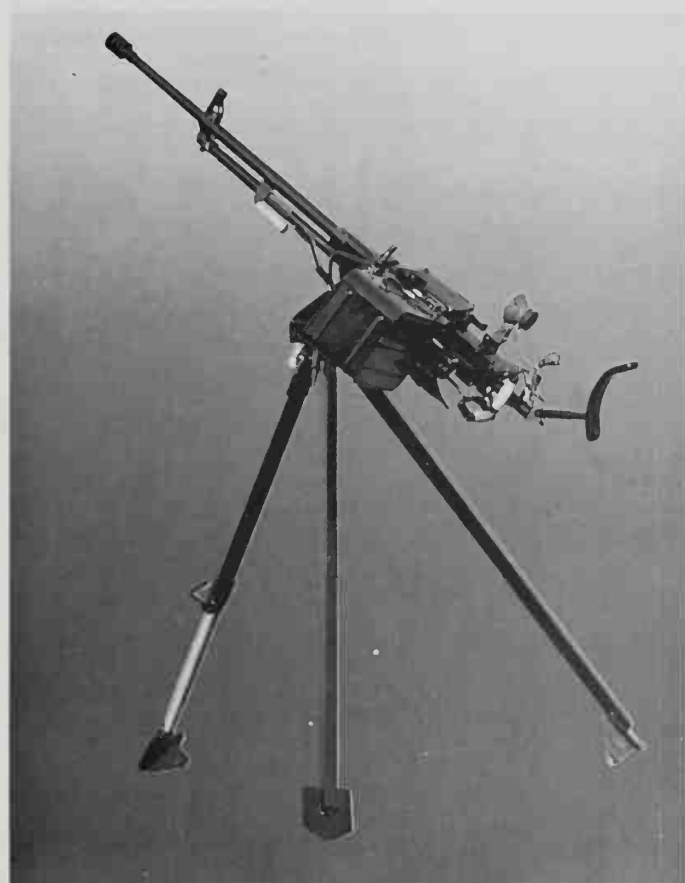
The 12.7 mm Type W-85 machine gun can be quickly stripped and reassembled without tools and the barrel can be quickly changed in the field. According to NORINCO, the machine gun mechanism has a malfunction rate not exceeding 0.2 per cent. The barrel is certified for 3500 rounds while the remainder of the weapon exceeds 7000 rounds.

The Type W-85 machine gun is fitted with an optical telescope enabling it to engage a wide range of battlefield targets under both day and night conditions. This can be replaced quickly by a special anti-aircraft sight.

The weapon can fire the following types of 12.7 mm × 107 ammunition, all with a muzzle velocity of 800 m/s: Type 54 armour-piercing, Type 54 armour-piercing with tracer and Type 54 armour-piercing incendiary. It can also fire the Type 54 tungsten alloy cored bullet with a muzzle velocity of 1150 m/s. Ammunition feed is from the left, with each metal box holding 60 rounds.

### SPECIFICATIONS

CALIBRE	12.7 mm
PRACTICAL RATE OF FIRE	80 to 100 rpm
WEIGHT OF SYSTEM	39 kg
WEIGHT OF GUN ONLY	18.5 kg
WEIGHT OF GUN MOUNT	15.5 kg
LENGTH IN HORIZONTAL FIRING POSITION	1.995 m
EFFECTIVE RANGE	
air targets	1600 m
ground targets	1500 m
TRAVERSE	
horizontal position	120°
air defence role	360°
ELEVATION IN HORIZONTAL POSITION	-15 to +25°
MAX ELEVATION	+80°



*NORINCO Type W-85 12.7 mm anti-aircraft machine gun in air defence configuration*

**Status:** In production. In service with Chinese Army.

**Manufacturer:** China North Industries Corporation, 7A Yuetan Nanjie, PO Box 2137 Beijing, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3471, 7570  
Telex: 22339 CNIN CN

## NORINCO 57 mm Type 59 Anti-aircraft Gun

### Development/Description

The Chinese 57 mm Type 59 anti-aircraft gun is a close copy of the Soviet 57 mm S-60 and differs in few details from the original. The Type 59 fires only one type of ammunition, HE-T. This HE-T round has a complete weight of 6.31 kg and a projectile weight of 2.8 kg. It has a muzzle velocity of 1000 m/s and is fitted with a Liu-2 nose fuze. The explosive charge is 0.153 kg of aluminised RDX. Chinese sources state that the Type 80 twin 57 mm self-propelled anti-aircraft gun system fires two types of ammunition; HET-PF (high-explosive tracer with percussion fuze) and APCT-BF (armour-piercing capped tracer with base fuze). It is probable that the Type 59 57 mm towed anti-aircraft gun can also fire this improved ammunition.

Time into action of the Type 59 is stated to be one minute and time to prepare for travelling is two minutes. A twin-barrel naval version known as the Type 66 is known to be in production. This utilises a water cooling system for the barrels and a chain-type hoist system for the ammunition.

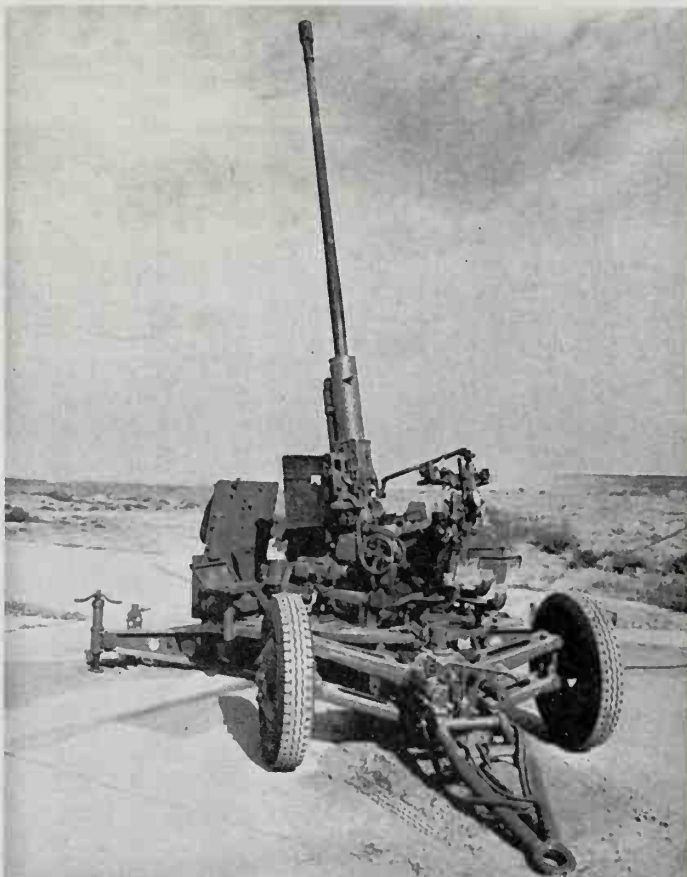
All the towed 57 mm systems use the Type GW-03 anti-aircraft fire control director. This four-wheel trailer-mounted system utilises a 3 m rangefinder with onboard computation facilities to control a complete battery of guns firing against either airborne or surface targets. The GW-03 can engage targets between 780 and 31 600 m. It can be coupled to a fire control radar if required. The Type 80 twin 57 mm self-propelled anti-aircraft gun system, fully described in the *Self-Propelled Anti-Aircraft Guns* section, uses the same gun and ammunition as the 57 mm Type 59 anti-aircraft gun.

### SPECIFICATIONS

CALIBRE	57 mm
BARREL LENGTH (overall)	4.39 m
MUZZLE BRAKE	multi-perforated
OPERATION	recoil full automatic
CARRIAGE	4-wheel
SHIELD	optional
WEIGHT (total)	4780 kg
LENGTH (travelling)	8.6 m
WIDTH (travelling)	2.07 m
HEIGHT (travelling)	2.46 m
MAX TOWING SPEED	35 km/h
ELEVATION/DEPRESSION	+85°/-5°
TRAVERSE	360°
LAYING SPEED (electrical)	
traverse	up to 24°/s
elevation	up to 15°/s
RATE OF FIRE (cyclic)	100-120 rpm
FEED	4-round clip
MAX RANGE (effective)	6000 m
CREW	7 or 8
TOWING VEHICLES	Type 59 artillery tractor, 6 × 6 heavy truck

**Status:** Production as required. In service with the Chinese Armed Forces and offered for export.

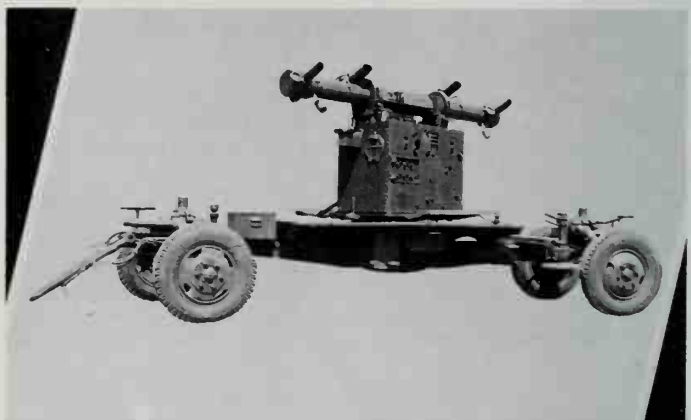
**Manufacturer:** China North Industries Corporation, 7A Yuetan Nanjie, PO Box 2137 Beijing, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3471, 7570  
Telex: 22339 CNIN CN



NORINCO 57 mm Type 59 anti-aircraft gun in firing position with ordnance at maximum elevation



NORINCO 57 mm Type 59 anti-aircraft gun towed by Type 59 artillery tractor



Type GW-03 anti-aircraft fire detector in travelling configuration

## NORINCO 37 mm Anti-aircraft Guns

### Development/Description

#### 37 mm Type 55

The most commonly encountered model of Chinese 37 mm anti-aircraft gun is the Type 55, a direct copy of the Soviet 37 mm M1939 from which it differs in few details. The ammunition used with the Type 55 is of two types, HE and HE-T. Both types of round weigh 1.416 kg, with the projectile weighing 0.732 kg. When fired from the Type 55, both have a muzzle velocity of 866 m/s and are fitted with the Liu-1 nose fuze.

#### 37 mm Type 65

The 37 mm Type 65 is a direct copy of the Soviet twin-barrelled version of the M1939 while the Type 74 is a model with revised detail engineering to suit Chinese manufacturing methods and can operate with radar fire control at a slightly increased rate of fire compared to the Type 65. The Type 65 and Type 74 use the same ammunition as the Type 55.

#### 37 mm Type 74

According to NORINCO the 37 mm twin-barrel Type 74 can be used to engage air targets within a slant range of 3500 m, and if required, ground targets.



The weapon is usually deployed in batteries of six guns with each battery being provided with a radar and fire director so that the gun can fire not only at visible targets but also targets above clouds and at night.

The Type 74 is fitted with an automatic vector sight which allows it to fire at air or ground targets by direct aiming.

The system can engage targets with a maximum speed of 300 m/s.

### 37 mm Type 74 SD

This is essentially the 37 mm Type 74 with the servo system and electric firing device removed, and an elevating and traversing mechanism and indicator dial being used in its place. Its effective slant range is 3000 m.

### 37 mm Type P793

The Type P793 is a twin-barrelled anti-aircraft gun based on the Type 74 but with many new features. The twin guns themselves have a higher rate of fire and are available with two types of barrel and rate of fire. The Type A gun has a muzzle velocity of 880 m/s while the Type B has a muzzle velocity of 1000 m/s. The rate of fire of a single P793 Type A barrel is 220 to 240 rds/min, while that of a Type B barrel is 270 to 300 rds/min. Both types of barrel continue to use Type 55 ammunition. The effective slant range for a Type A is 3500 m while for the Type B it is 4000 m. Recent information has indicated that NORINCO is now only offering the Type A gun version.

The P793 carriage has its own generator powered by an engine developing 7 hp at 3750 rpm. The generator powers the carriage electrical controls and also the electro-optical sight system. The sight is known as the JM 831 and appears to be of the Officine Galileo pattern having a  $\times 5$  magnification and a  $12^\circ$  field-of-view. The P56 is stated to be a self-powered electro-optical aiming sight which takes three to four seconds to be ready for firing once a target has been detected. The sight can cope with target velocities of 60 to 350 m/s. Maximum lead angle is  $25^\circ$ . Target ranges are between 100 and 1500 m, while ground target maximum range is 3000 m. Maximum barrel angular acceleration for traverse is  $95^\circ/\text{s}^2$ , while that for elevation is  $80^\circ/\text{s}^2$ . Mechanical elevation is from  $-5$  to  $+87^\circ$  while powered elevation is from  $-0$  to  $+82.5^\circ$ .

The P793 has 182 rounds stored on the carriage and has a crew of five or six. It can be towed at speeds of up to 60 km/h on roads or 25 km/h on dirt roads. Weight of the P793 is 3100 kg.

### 37 mm Ammunition

The Type 74, Type 74 SD and the Type P793 all use the following types of fixed ammunition which are called the Type 55:

Type	HE-T	AP-T	HE	AP/HE
Length	381.88/384.97 mm	382.49/386.22 mm	386 mm	n/av
Weight of round	1.417 kg	1.444 kg	1.417 kg	1.44 kg
Weight of projectile	0.732 kg	0.758 kg	0.732 kg	0.755 kg
Muzzle velocity	866 m/s	880 m/s	866 m/s	868 m/s
Max chamber pressure	2800 kg/cm <sup>2</sup>	2900 kg/cm <sup>2</sup>	2800 kg/cm <sup>2</sup>	2900 kg/cm <sup>2</sup>
Tracer duration	6 s	6 s	nil	6 s
Compatible fuze	ML-1	nil	ML-1	nil
Maximum slant range	8500 m	8500 m	8500 m	8500 m
Maximum firing altitude	6700 m	6700 m	6700 m	5000 m
Effective firing altitude	3000 m	3000 m	3000 m	1500 m

#### Notes:

- (a) All rounds have a temperature range of  $-40$  to  $+50^\circ\text{C}$   
 (b) AP-T round will penetrate 40 mm armour at an angle of  $30^\circ$   
 (c) AP/HE round will penetrate 25 mm of armour at an angle of  $30^\circ$ .

### Pakistani 37 mm upgrade

Pakistan has around 700 Chinese-supplied 37 mm light anti-aircraft guns fitted with their original manual controls and optical sights. To improve their capability to engage fast low flying jet aircraft Pakistan has embarked on a major modernisation programme which covers the installation of a new gun control and fire control system.

Three Western companies were each supplied with a Chinese-built twin 37 mm system which were then upgraded and tested by the respective manufacturers prior to being shipped to Pakistan for extensive tracking and firing trials. These were completed in mid-1989.

Contraves Italiana fitted their Gun King sight which is already in volume production for a number of weapons including the Oerlikon-Contraves twin 35 mm GDF series of towed anti-aircraft guns. Bofors Aerotronics have fitted their UTAAS fire control system which is being installed in a version of the new Swedish Army Combat Vehicle 90 while Officine Galileo have fitted their new Vanth/MB sight which is a further development of the P75. Details of these sights are given in the *Towed Anti-Aircraft Gun Sights* section. Although Pakistan has around 700 twin 37 mm towed anti-aircraft gun systems it is likely that initially around 200 systems will be upgraded. The first sights would come from abroad but in the longer term, the aim would be to make most of them in Pakistan.



NORINCO Twin 37 mm anti-aircraft gun Type 65 in firing position



Chinese twin 37 mm LAAG fitted with shield and captured in Kuwait (Christopher F Foss)



NORINCO 37 mm Type P793 in firing position with outriggers extended



Chinese twin 37 mm LAAG fitted with shield from rear showing ready use ammunition boxes on rear of mount (Christopher F Foss)

### Fire Control Systems

All the 37 mm towed systems can be coupled to a fire control radar. Known as the Type 311A, this uses a four-wheel trailer van with an I/J-band search, acquisition and tracking radar antenna on a roof-mounted pedestal. The set operates on three preselected frequencies which can be manually switched without any adjustments. Minimum and maximum ranges are 500 and 30 000 m respectively, against low radar cross-section fighter sized targets with speeds of less than 550 m/s. An 8 t truck is needed to tow the 4 t trailer and this carries the ancillary equipment and the power supply generator. The radar is also used with the 57 mm towed systems. Further development of the Type 311 has led to the Type 311B and Type 311C models. The Type 311B introduces an integral IFF system, increased frequency coverage and a maximum detection range of 35 000 m using a new antenna design. The Type 311C goes one stage further and has a frequency agile capability radar with a maximum range of 40 000 m. The minimum range stays the same in both cases.

### Type 80 Weapon System

This system essentially consists of six twin 37 mm Type 74 light anti-aircraft guns coupled to a central distribution box, power supply units and a fire control radar Type 702. The system has been designed to engage air targets with a slant range of 3500 m but can also be used to engage ground and water targets.



China National Electronics Import & Export Corporation Type 311A fire control radar system

The trailer-mounted Type 702 fire control system searches and tracks the targets, calculates the firing data and then passes this information onto the guns with the fire control radar deciding when to open fire.

The system has four modes of operation: automatic, semi-automatic, manual align of indicator and manual aiming.

The Type 702 system comprises the roof-mounted fire control radar, digital fire control computer, TV monitor, main power supply unit and an auxiliary power supply unit.

The fire control radar has a maximum target detection range and target tracking range of 40 km. Its range tracking error is 15 m with range tracking speed being a maximum of 600 m/s. The digital fire control computer installed is an Intel 8086.

### Type 80 Air Defence Network

This system consists of three six-gun batteries of twin 37 mm Type 74 light anti-aircraft guns, a Type 801 director, a Type 702 fire control radar and a Type 703 battalion C<sup>3</sup>I (command, control, communication and information) system.

#### Type 801 director

This comprises an optical sight, laser rangefinder, laser data processor, single joystick tracker, a micro-computer, instrument truck and a power supply unit. The system is mounted on a four-wheeled trailer.

Its optical sight has a magnification of  $\times 10$  and a  $7^\circ$  field-of-view and a viewing range of 15 km, while the laser rangefinder has a maximum range of 7000 m and a ranging error of 5 m. The system also incorporates an Intel 8086 microprocessor and a power generating system.

#### 35 mm version

In 1991 NORINCO stated that some of these twin 37 mm light anti-aircraft gun systems were also available in twin 35 mm calibre and firing standard NATO ammunition types.



Type 702 fire control radar deployed with stabilisers lowered



37 mm Type 74 anti-aircraft gun in firing position

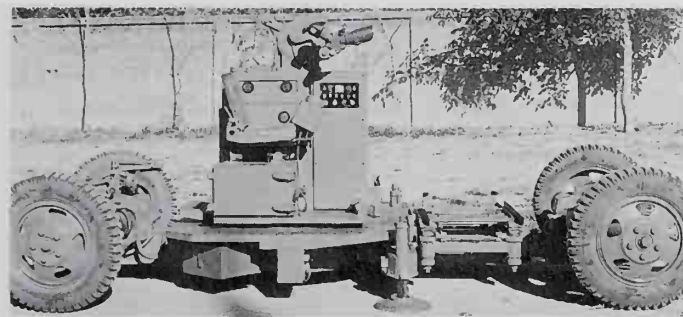


## Type 390 Integrated Gun/Missile Air Defence System

This system includes twin 37 mm light anti-aircraft guns, Type 702 fire control systems, Type 801 director, command systems and the Ibis low altitude search radar together with a ground-launched version of a PL-9 air-to-air missile.

### SPECIFICATIONS

DESIGNATION	Type 65	Type 74
CALIBRE	37 mm	37 mm
BARREL LENGTH (approx)	2.73 m	2.73 m
OPERATION	recoil	recoil
RECOIL	hydraulic recoil buffer and spring recuperator	
BREECH MECHANISM	rising block	rising block
CARRIAGE	4-wheel	4-wheel
SHIELD	no	no
WEIGHT (total)	2700 kg	3040 kg
LENGTH (travelling)	6.36 m	6.205 m
WIDTH (travelling)	1.80 m	1.816 m
HEIGHT (travelling)	2.25 m	2.28 m
MAX TOWING SPEED	35 to 60 km/h	35 km/h
ELEVATION/DEPRESSION		
manual drive	+85°/-10°	+87°/-5°
electric drive	n/app	+81.5°/0°
TRAVERSE	360°	360°
TRAVERSE LAYING SPEED		
manual, rate 1	n/av	15.21°/turn
manual, rate 2	n/av	25.16°/turn
automatic	n/app	up to 50°/s
ELEVATION LAYING SPEED		
manual	n/av	9.08°/turn
automatic	n/app	up to 30°/s
RATE OF FIRE		
(both barrels)	320-360 rpm	440-480 rpm
FEED	5-round clip	5-round clip
EFFECTIVE SLANT RANGE	3500 m	3500 m



Type 801 director deployed in position with outriggers extended

### SPECIFICATIONS

	Type 65	Type 74
MAX RANGE		
vertical	6700 m	6700 m
horizontal	8500 m	8500 m

**Status:** All are in production and service with the Chinese Armed Forces. Chinese 37 mm anti-aircraft guns have been exported in some numbers but as they are almost identical to the Soviet weapons, the following list of users should be taken as provisional:

Type 55 - Gabon, Guinea, North Korea, Mozambique, Pakistan, Sudan, Tanzania, Tunisia and Zambia

Type 63 - Cameroon, Iraq and Zaire

Type 68 - Mozambique

Type 74 - 60 (10 × 6 gun batteries) Thailand. An additional 18 systems were ordered for the Royal Thai Air Force in 1988.

**Manufacturer:** China North Industries Corporation, 7A Yuetan Nanjie, PO Box 2137 Beijing, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3471, 7570  
Telex: 22339 CNIN CN

## NORINCO 25 mm Light Anti-aircraft Gun Type 85

### Development/Description

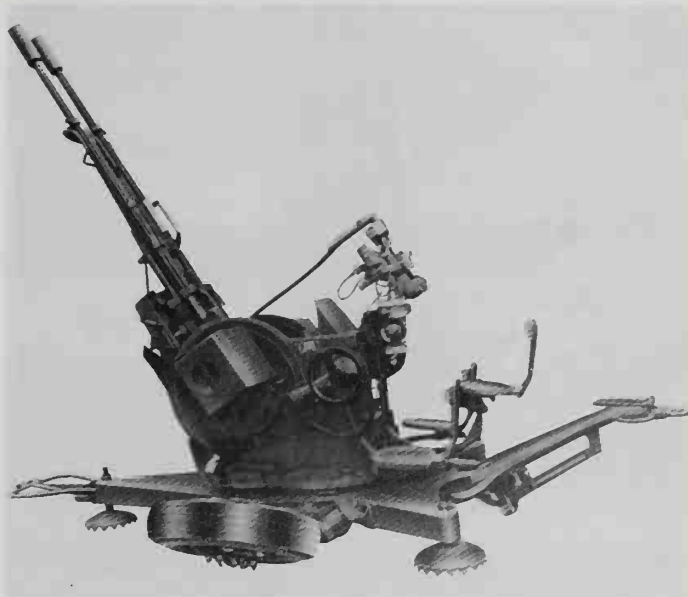
For some time now, China has been producing a copy of the Soviet twin 23 mm ZU-23 light anti-aircraft gun, but at Asiandex 86 a new twin 25 mm calibre towed low altitude defence anti-aircraft gun was unveiled, which is believed to have the designation WA709. Other sources have stated that this is designated the WA309, with the Chinese Army designation being Type 85.

This is very similar to the ZU-23 with distinctive parallel flash eliminators and a handle on each barrel to facilitate a quick change.

It has a crew of three with the elevation operator on the left, the commander in the centre and the traverse operator on the right. The elevation and traverse controls are manual and the cannon has a muzzle velocity of 1050 m/s. The fixed ammunition types used are HE-T, AP-T and HEAP-T.

### SPECIFICATIONS

CALIBRE	25 mm
OPERATION	gas, full automatic
CARRIAGE	2-wheeled
SHIELD	no
WEIGHT (travelling)	
with ammunition	1500 kg
LENGTH (travelling)	4.68 m
WIDTH (travelling)	2.04 m
HEIGHT (travelling)	2.08 m
ELEVATION/DEPRESSION	+90°/-10°
TRAVERSE	360°
RATE OF FIRE PER BARREL (cyclic)	600-700 rpm
MAX RANGE (vertical)	5000 m
EFFECTIVE VERTICAL RANGE	
RANGE	3200 m
CREW	3 plus off mount loaders
TOWING VEHICLE	4 × 4 vehicle



NORINCO twin 25 mm light anti-aircraft gun in firing position

**Status:** Believed to be in production and in service with the Chinese Army.

**Manufacturer:** China North Industries Corporation, 7A Yuetan Nanjie, PO Box 2137 Beijing, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3741, 7570  
Telex: 22339 CNIN CN

## NORINCO 23 mm Light Anti-aircraft Gun Type 80

### Development/Description

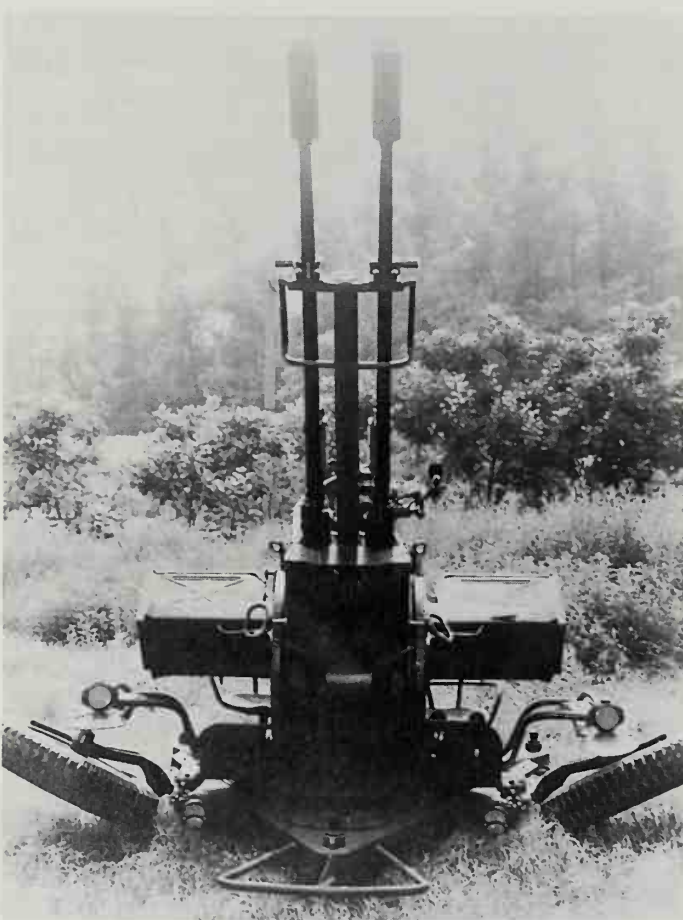
The Chinese 23 mm light anti-aircraft gun Type 80 has been in production for many years and is a reverse engineered copy of the Soviet ZU-23 with several minor differences to suit Chinese manufacturing processes.

The gun is operated by a crew of two on the mount and three off who serve as ammunition carriers and loaders for the two metallic linked 50-round ammunition belts in the box magazines.

In all operational respects, the gun is similar to the Soviet weapon and it is effective against low flying targets at ranges up to 2500 m and an altitude of 1500 m. It can also be used to engage ground targets out to 2000 m effective range.

The cannon fire two types of 0.236 m long 0.45 kg fixed ammunition. Both are copies of the standard Soviet ammunition used with the ZU-23.

The 23 mm HEI-T round is fitted with a nose-mounted fuze that contains a self-destruct device. The projectile is filled with Hexal with a tracer in its rear end. The fuze delaying mechanism ensures that the projectile only explodes after penetrating the target. If the projectile fails to penetrate the target then it will automatically explode in 5 to 11 seconds under the action of the self-destruct device.



NORINCO 23 mm Type 80 light anti-aircraft gun in firing position

The 23 mm API-T round penetrates the target first and then damages it with fragmented armour pieces and the projectile itself.

Both rounds have the same ballistics, and HEI-T and API-T rounds are normally incorporated into belts in a ratio of 3:1.

Basic specifications of the 23 mm ammunition are:

CALIBRE	23 mm
TOTAL LENGTH	236 mm
TOTAL WEIGHT OF ROUND	450 g
WEIGHT	
HEI-T projectile	188.5 g
API-T projectile	190 g
TRACER BURNING TIME	5 s
FUZE SELF-DESTRUCT WEIGHT	5 to 11 s
HEI-T explosive	13 g
API-T incendiary charge	4.3 g

### Type 80 system

This essentially comprises a battery of six 23 mm Type 80 light anti-aircraft guns used in conjunction with the Type 801 laser course director as mentioned and illustrated in the previous entry.

### SPECIFICATIONS

CALIBRE	23 mm
BARREL LENGTH (overall)	2.01 m
MUZZLE VELOCITY	970 m/s
MAX CHAMBER PRESSURE	3100 kg/cm <sup>2</sup>
OPERATION	gas, full automatic
BREECH MECHANISM	vertical sliding wedge
CARRIAGE	2-wheeled
SHIELD	none
WEIGHT	
(travelling order with ammunition)	950 kg
(firing position with ammunition)	950 kg
LENGTH	
travelling	4.57 m
firing	4.57 m
WIDTH	
travelling	1.83 m
firing	2.88 m
HEIGHT	
travelling	1.87 m
firing	1.82 m
ELEVATION/DEPRESSION	+85°/-4°
TRAVERSE	360°
RATE OF FIRE PER BARREL	
cyclic	800-1000 rpm
practical	200 rpm
FEED	50-round belt
MAX RANGE	
horizontal	7000 m
vertical	5100 m
EFFECTIVE RANGE	
horizontal	2000 m
vertical	2500 m
CREW	5
TOWING VEHICLE	4 × 4 vehicle

**Status:** In production. In service with the Chinese Armed Forces.

**Manufacturer:** China North Industries Corporation, 7A Yuetan Nanjie, PO Box 2137 Beijing, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3471, 7570  
Telex: 22339 CNIN CN

## NORINCO 14.5 mm Anti-aircraft Guns

### Development/Description

#### Type 56 LAAG

The Chinese 14.5 mm anti-aircraft guns all use the Chinese version of the Soviet KPV heavy machine gun. The 'base' model as far as Chinese production is concerned is the Type 56, a direct copy of the Soviet ZPU-4. The Type 56 fires three types of ammunition, API, API-T and Incendiary, all identical to their Soviet counterparts. The Type 56 has been exported widely and is also produced in North Korea.

#### Type 58 LAAG

The Type 58 is a direct copy of the Soviet ZPU-2 and resembles the late production version of the Soviet original.

#### Type 75 LAAG

The Type 75 is the Chinese version of the ZPU-1 and is designed to be pack transported if necessary. The Type 75-1 has a more complex optical sight which may have image intensification characteristics.

#### Type 80 LAAG

The Type 80 is a version of the ZPU-1, re-engineered to Chinese standards and with a redesigned carriage which enables it to be fired from the prone position against ground targets. It has a more robust carriage than either of the Type 75s and may be towed behind a light 4 × 4 vehicle.

The Types 58, 75, 75-1 and 80 all fire the same ammunition as the Type 56.





NORINCO 14.5 mm Type 58 anti-aircraft machine gun in travelling position

**SPECIFICATIONS**

	Type 56	Type 58
DESIGNATION		
CALIBRE	14.5 mm	14.5 mm
NUMBER OF BARRELS	4	2
BARREL LENGTH	1.348 m	1.348 m
CARRIAGE	4-wheel	2-wheel
WEIGHT	2100 kg	660 kg
LENGTH	4.54 m	3.9 m
WIDTH	1.86 m	1.66 m
HEIGHT	2.34 m	1.1 m
ELEVATION/DEPRESSION	+90°/-10°	+90°/-15°
TRAVERSE	360°	360°
RATE OF FIRE (all barrels)	2200 rpm	1100 rpm
MAX EFFECTIVE RANGE		
air target	2000 m	2000 m
ground target	1000 m	1000 m
AMMUNITION BOX CAPACITY	150 rounds	150 rounds
MUZZLE VELOCITY	995 m/s	995 m/s

**Status:** Production. In service with the Chinese Armed Forces and other armed forces including Cameroon (18). Offered for export. The Type 80 LAAG has also been used by Afghan resistance fighters.



NORINCO 14.5 mm Type 80 anti-aircraft machine gun in travelling position



NORINCO 14.5 mm Type 75-1 anti-aircraft machine gun in firing position

	Type 75	Type 75-1	Type 80
DESIGNATION			
CALIBRE	14.5 mm	14.5 mm	14.5 mm
NUMBER OF BARRELS	1	1	1
BARREL LENGTH	1.348 m	1.348 m	1.348 m
CARRIAGE	tripod	2-wheel	2-wheel
WEIGHT	140 kg	165 kg	214 kg
LENGTH	2.93 m	2.93 m	2.5 m
WIDTH	1.62 m	1.62 m	1.8 m
HEIGHT	1.07 m	1.27 m	2.2 m
ELEVATION/DEPRESSION	+85°/-10°	+85°/-10°	+85°/-15°
TRAVERSE	360°	360°	360°
RATE OF FIRE	550 rpm	550 rpm	550-600 rpm
MAX EFFECTIVE RANGE			
air target	2000 m	2000 m	2000 m
ground target	1000 m	1000 m	1000 m
AMMUNITION BOX CAPACITY	80 rounds	80 rounds	80 rounds
MUZZLE VELOCITY	995 m/s	995 m/s	995 m/s

**Manufacturer:** China North Industries Corporation, 7A Yuetan Nanjie, PO Box 2137 Beijing, Beijing, People's Republic of China.  
Telephone: (86) 6898, 3461, 3471, 7570  
Telex: 22339 CNIN CN



NORINCO 14.5 mm Type 56 anti-aircraft machine gun in travelling position

## CZECHOSLOVAKIA

## 30 mm Automatic Anti-aircraft Gun M53

## Development/Description

The 30 mm automatic anti-aircraft gun M53 is used by Czechoslovakia in place of the Soviet 23 mm ZU-23 anti-aircraft gun and entered service in the late 1950s. The Czechoslovakian weapon is heavier than the Soviet ZU-23 and has a slower rate of fire, but its effective anti-aircraft range is 3000 m compared with the ZU-23's 2500 m.

In action, the four wheels are raised off the ground and the carriage is supported on four jacks, one at the front, one at the rear and one each side on outriggers. The guns are gas-operated, fully automatic and are fitted with quick-change barrels. Ammunition is fed horizontally in clips of 10 rounds. The following types of fixed ammunition can be fired: API with the projectile weighing 0.54 kg and a muzzle velocity of 1000 m/s, which will penetrate 55 mm of armour at an incidence of 0° at a range of 500 m, and HEI with the projectile weighing 0.45 kg and a muzzle velocity of 1000 m/s. The M53 is a clear-weather system only with no provision for radar control.

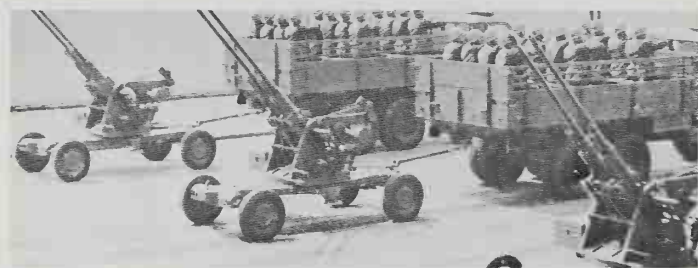
There is also a self-propelled model of the M53 called the M53/59 based on an armoured Praga V3S (6 × 6) truck which is described in the *Self-Propelled Anti-Aircraft Guns* section. The guns of the M53/59 have a higher rate of fire as the vertical magazines each hold 50 rounds of ammunition in clips of 10 rounds.

## Variant

The Cuban Army has modified a number of BTR-60P (8 × 8) armoured personnel carriers to carry the Czechoslovakian twin 30 mm automatic anti-aircraft gun system M53.

## SPECIFICATIONS

CALIBRE	30 mm
BARREL LENGTH (overall)	2.429 m
MUZZLE BRAKE	multi-baffle
CARRIAGE	4-wheel with outriggers
SHIELD	no
WEIGHT	
travelling order	2100 kg
firing position	1750 kg



30 mm automatic anti-aircraft guns M53 in travelling order

LENGTH (travelling)	7.587 m
WIDTH (travelling)	1.758 m
HEIGHT (travelling)	1.575 m
AXIS OF BORE (firing)	0.86 m
GROUND CLEARANCE (travelling)	0.3 m
TRACK	1.575 m
ELEVATION/DEPRESSION	+85°/-10°
TRAVERSE	360°
RATE OF FIRE PER BARREL	
cyclic	450-500 rpm
practical	100 rpm
FEED	10-round clip
MAX RANGE	
horizontal	9700 m
vertical	6300 m
EFFECTIVE VERTICAL RANGE	3000 m
CREW	4
TOWING VEHICLE	Praga V3S (6 × 6) truck

**Status:** Production complete. In service with the following countries:

Country	Quantity	User	Comment
Czechoslovakia	n/av	army	some in reserve
Cuba	100	army	status uncertain
Guinea	n/av	army	unconfirmed user
Romania	300	army	
Vietnam	150	army	probably in reserve
Yugoslavia	n/av	army	status uncertain

**Manufacturer:** Czechoslovakian state factories.



30 mm automatic anti-aircraft gun M53 defending Bar Lock radar installation

## Quad 12.7 mm M53 Anti-aircraft Machine Gun

## Development/Description

This anti-aircraft gun was developed in Czechoslovakia in the 1950s and is essentially a two-wheeled carriage fitted with four Soviet 12.7 mm M1938/46 DShKM machine guns.

In the firing position the two rubber-tired road wheels are removed and the weapon is supported on three outriggers. The M53 fires an API projectile weighing 49.5 g with a muzzle velocity of 840 m/s, which will penetrate 20 mm of armour at an incidence of 0° at a range of 500 m.

The M53 is no longer in front-line service with Czechoslovakia. The Egyptian Army had a number of BTR-152 (6 × 6) armoured personnel carriers fitted with the quad 12.7 mm M53 anti-aircraft machine gun system in the rear and having full 360° traverse. These are no longer in front-line service with Egypt but a number have been encountered recently in Afghanistan. A photograph of this version appears in the BTR-152 entry in the *Self-Propelled Anti-Aircraft Guns* section. There is also a Czechoslovakian twin-barrelled version mounted on a Soviet UAZ-469 (4 × 4) light vehicle, but its exact status is uncertain.

The 12.7 mm anti-aircraft machine gun has an effective slant range of 1006 m. Effective altitude limit with an elevation of +45° is 671 m, while effective altitude limit with an elevation of +65° is 914 m.

## SPECIFICATIONS

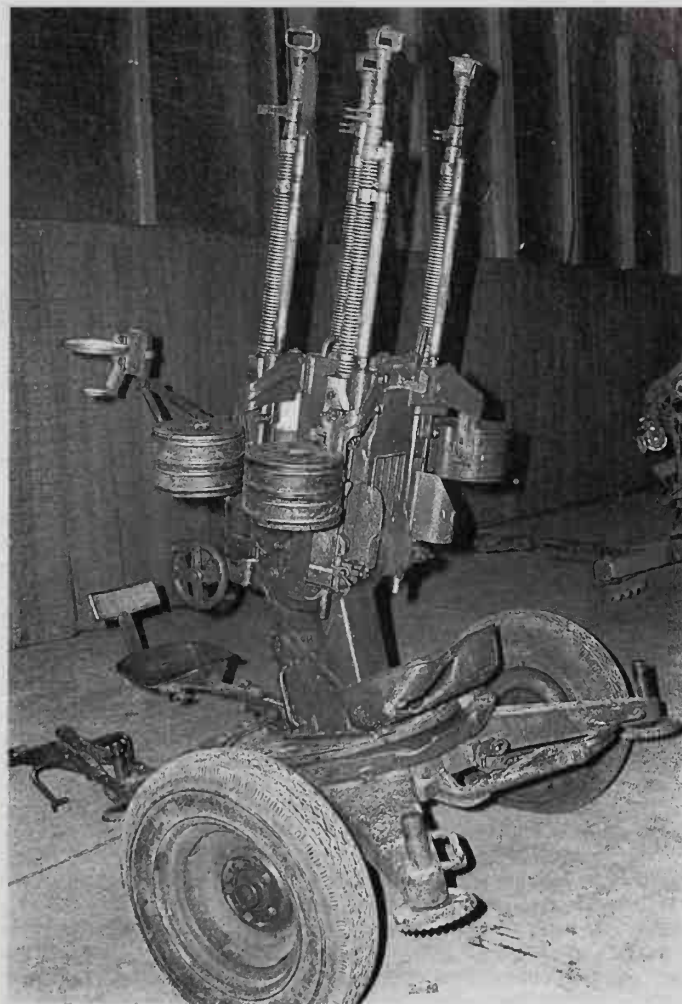
CALIBRE	12.7 mm
BARREL LENGTH	
without muzzle brake	0.967 m
with muzzle brake	1.588 m
MUZZLE BRAKE	yes
OPERATION	gas, automatic
CARRIAGE	2-wheeled with outriggers
SHIELD	no
WEIGHT	
travelling order	2830 kg
firing position	628 kg
LENGTH (travelling)	2.9 m
WIDTH (travelling)	1.57 m
HEIGHT (travelling)	1.78 m
TRACK	1.5 m
TYRES	5.00 × 16
ELEVATION/DEPRESSION	+90°/-7°
TRAVERSE	360°
RATE OF FIRE PER BARREL	
cyclic	540-600 rpm
practical	80 rpm



FEED	50-round belt in drum
MAX RANGE	
horizontal	6500 m
vertical	5600 m
EFFECTIVE VERTICAL RANGE	1000 m
UNIT OF FIRE	2000 rounds
CREW	6
TOWING VEHICLE	GAZ-69 (4 × 4) truck

**Status:** Production complete. In service with Cuba (Army, reserve), Egypt (Army, reserve), Vietnam (Army, reserve) and other countries in the Middle and Far East. Has also been observed in Afghanistan mounted in the rear of BTR-152 (6 × 6) APCs.

**Manufacturer:** Czechoslovakian state factories.



*Quad 12.7 mm M53 anti-aircraft machine gun captured by US forces in Grenada with stabilisers raised in travelling configuration and showing drums each holding 50 rounds (US Army)*

## EGYPT

### ZU-23M Twin 23 mm Automatic Anti-aircraft Gun

#### Development/Description

The ZU-23M is essentially the Soviet 23 mm ZU-23 (see entry later in this section) produced under licence at Heliopolis in Egypt by Abu Zaabal Engineering Industries (Factory 100). It differs only slightly from the Soviet original and fires the same ammunition. It has also been referred to as the SH-23M.



*Egyptian-built 23 mm ZU-23M in firing position (Christopher F Foss)*

The ZU-23M has a five-man detachment, two of whom are on the weapon, one on either side of the mount and the other three off the carriage with two of these acting as ammunition members. Each barrel is fed from a 50-round belt of ammunition in a steel magazine, a new magazine can be loaded in 10 seconds. The ammunition feeding system has been designed to prevent the firing of the last round and the moving parts stay to the rear ready to receive the first round of the new belt so that firing can start immediately.

The ZU-23M twin 23 mm towed anti-aircraft gun can engage aircraft and helicopters at altitudes of up to 1500 m and ranges of up to 2500 m. Lightly armoured ground targets can be engaged out to a maximum range of 2500 m.

The weapon is fitted with a sighting device to calculate the future position of targets up to a speed of 300 m/s. The sighting device is also provided with a direct fire telescope to engage both stationary and moving ground targets.

The twin 23 mm cannon used in the system are manufactured by the Maadi Co for Engineering Industries (also called Factory 54).

All specifications are identical to those of the original Soviet weapon but the Egyptians provide the following additional information:

CREW	5 men
MAX TOWING SPEED	70 km/h
TIME TAKEN TO BRING INTO ACTION	15-20 s
TIME TAKEN TO COME OUT OF ACTION	35-40 s

#### Variants

#### Ramadan 23

In 1987 Factory 100 and Contraves of Italy fitted two ZU-23Ms with the Contraves Gun King laser/computer sighting system, which is already in volume production for a number of other applications including the Oerlikon-Contraves twin 35 mm GDF towed anti-aircraft gun system.

The Egyptians call the ZU-23M/Gun King combination the Ramadan and firing trials were completed in late 1987.

Ramadan 23 has just one man on the mount, with full power control by an onboard electric motor powered by an off-carriage generator. One man can control two ZU-23Ms with not only greater response but with a greatly enhanced kill probability. Full details of the Contraves Gun King sight are given in the *Towed Anti-Aircraft Gun Sights* section.

### Self-propelled Twin 23 mm System

This uses the basic 23 mm ZU-23 cannon and is covered in the *Self-Propelled Anti-Aircraft Guns* section under Egypt.

**Status:** In production. In service with the Egyptian and Sudanese Armed Forces and is offered for export.

**Manufacturer:** Abu Zaabal Engineering Industries Company, PO Box 5888, Heliopolis West, Cairo, Arab Republic of Egypt  
Telephone: 2917305/2917033  
Telex: 22595 AZED UN  
Fax: 2916962

## FRANCE

### GIAT Industries 53T4 Twin 20 mm Automatic Anti-aircraft Gun

#### Development/Description

First shown publicly at the 1983 Satory Exhibition, the GIAT Industries 53T4 is an anti-aircraft weapon intended for the defence of local areas, or of convoys with the guns and mounting removed from the carriage and placed on a truck.

The 53T4 is a twin-barrelled weapon mounting two 20 mm cannon side by side. The guns and carriage can be towed across country and brought into action by moving the two road wheels towards the towbar and laying them flat. The carriage is then supported on a pad under the towbar and two further pads on jacks carried by short outrigger arms. If required, the mounting can be lifted from the carriage and carried on a truck flat bed. The carriage may then be used as an ammunition limber, towed behind the truck. In action the gun may be hydraulically powered or manually traversed and elevated. Maximum speed of hydraulic aiming is 80°/s in azimuth and 50°/s in elevation. In the manual mode, one turn of the traverse handwheel moves the barrels 10.5° and a turn of the elevation handwheel elevates the barrels 6.5°. The gunner sits to the left of the barrels and moves with them and the gun sight to align himself and the barrels rapidly with a target. Firing is electrical and cut-out switches can be set to prevent firing over selected arcs. The anti-aircraft sight has a magnification of  $\times 1$  and has an off-set graticule to compensate for target speeds. For use against ground targets, a  $\times 5.2$  magnification telescope is provided. Hydraulic re-cocking of the guns is available.

The 53T4 uses two 20 mm CN-MIT 20 M693 ACA cannon with a combined rate of fire of 1800 rds/min. Ammunition is fed into the guns from two 150-round boxes loaded with HE rounds in belts, but a further 50 AP

rounds are held in readiness on the gun. Each belt has an end-stop device to assist reloading.

If required the 53T4 can be fired direct from the carriage wheels.

#### Variant

The prototype of the 53T4 was shown for the first time in mid-1987, with its twin 20 mm cannon replaced by a single GIAT Industries 25 mm Model 811 cannon.

#### SPECIFICATIONS

CALIBRE	20 mm
WEIGHT (with ammunition and gunner)	2000 kg
ELEVATION/DEPRESSION	+83°/-8°
TRAVERSE	360°
MANUAL LAYING	
traverse	10.5° per rotation of wheel
elevation	6.5° per rotation of wheel
MAX LAYING SPEED (hydraulic)	
traverse	80°/s
elevation	50°/s
RATE OF FIRE	
(per barrel, cyclic)	900 rpm
FEED	2 $\times$ 150-round belts in boxes 2 $\times$ 20 AP rounds on carriage
CREW (on gun)	1

**Status:** Development complete. Not yet in production or service.

**Manufacturer:** GIAT Industries, 13 route de la Minière, F-78034 Versailles Cedex, France.  
Telephone: (1) 30 97 37 37  
Fax: (1) 30 97 39 00



Prototype of GIAT Industries 53T4 with twin 20 mm cannon replaced by single GIAT Industries 25 mm Model 811 cannon



GIAT Industries 53T4 20 mm twin anti-aircraft gun showing method of wheel stowage when emplaced and spare ammunition box stowage

### GIAT Industries Cerbere 76T2 Twin 20 mm Automatic Anti-aircraft Gun

#### Development/Description

The Cerbere twin 20 mm automatic anti-aircraft gun is essentially the German Rheinmetall twin 20 mm system, with the original Rh 202 cannon replaced by the French M693(F2). A full description of the mount is given in the entry for the original German system in this section.

The French designation for the Cerbere is the 76T2. It has been adopted by the French Air Force for close-range protection of airfields with Crotale SAM batteries. A total of 299 systems were delivered to the

French Air Force between 1980 and 1985. Somalia ordered a total of 40 systems.

In a more advanced version the mounting can be integrated in a defence system and directed automatically at the target, either by a surveillance radar, or a director equipped with a DALDO target indicator helmet.

#### SPECIFICATIONS

CALIBRE	20 mm
OPERATION	delayed blowback with locked breech
CARRIAGE	2-wheeled with outriggers
SHIELD	yes



<b>WEIGHT</b>	
in travelling order without ammunition	2150 kg
in firing position with ammunition	1600 kg
<b>LENGTH</b>	
travelling	5.05 m
firing	4.02 m
<b>WIDTH</b>	
travelling	2.39 m
firing	2.06 m
<b>SWEPT RADIUS (at 0° elevation)</b>	2.48 m
<b>HEIGHT</b>	
travelling	2.075 m
firing	1.67 m
<b>AXIS OF BORE (firing)</b>	0.765 m
<b>ELEVATION/DEPRESSION</b>	
powered	+81.5°/-3.5°
manual	+83°/-5°
<b>TRAVERSE</b>	360°
<b>RATE OF FIRE (cyclic)</b>	900 rpm, per barrel
<b>FEED</b>	dual selectable belt feed with disintegrating links, 270 rounds per barrel
<b>EFFECTIVE AA RANGE</b>	2000 m
<b>CREW</b>	3 (1 on mount)
<b>TOWING VEHICLE</b>	4 × 4 truck

**Status:** Production complete but can be resumed if further orders are placed. In service with the Somalian Army (40) and the French Air Force (299).



GIAT Industries Cerbere 76T2 twin 20 mm automatic anti-aircraft gun in firing position

**Manufacturer:** GIAT Industries, 13 route de la Minière, F-78034 Versailles Cedex, France.

Telephone: (1) 30 97 37 37

Fax: (1) 30 97 39 00

## GIAT Industries Tarasque 53T2 20 mm Automatic Anti-aircraft Gun

### Development

The Tarasque 20 mm automatic anti-aircraft gun, official designation 53T2, has been selected as the standard weapon in its class for the French Army and first production weapons were delivered in 1982. The system is armed with a single 20 mm French M693(F2) cannon which is also installed in the Cerbere twin 20 mm automatic anti-aircraft gun, certain versions of the AMX-30 MBT, the AMX-10P IFV and the South African Ratel 20 IFV.

### Description

Although designed primarily for anti-aircraft use, Tarasque can also be used against personnel and light armoured vehicles. Its low weight makes it easily transportable across rough country and it can also be carried slung under a helicopter.

A heat motor-driven rotary pump charges an oil receiver supplying the traversing and elevation hydraulic motors and the hydraulic recocking mechanism. If the motor is unserviceable the receiver can be charged by a hand-operated pump. Maximum powered traverse speed is 40°/s. Handwheels are also fitted for emergency use; one turn of one handwheel gives 10° of traverse and one turn of the other gives 6.5° in elevation.

The gunner can select either single shots or full automatic, with the hydraulic firing mechanism actuated by the gunner depressing his right foot. Safety controls, ammunition selector and hydraulic reloading controls are to the right of the gunner's position. On the forward part of the mount on the left side, are two discs adjustable to within 25 mils, to prevent the gun being fired in predetermined zones.

The M348 sight includes an anti-aircraft sight with a magnification of × 1 and a ground sight with a magnification of × 5.2.

The M693(F2) cannon has dual feed, with the weapon provided with 90 rounds of HE/HEI ammunition and 40 rounds of APDS ammunition. Standard HSS 820 ammunition can be fired, including APDS (French designation OPT-SOC) with a muzzle velocity of 1293 m/s, HEI (French designation OEI) with a muzzle velocity of 1050 m/s, HEI-T (French designation OEIT) with a muzzle velocity of 1050 m/s, Practice Tracer (French designation OXT) and Practice Inert (French designation OX). The APDS projectile will penetrate 20 mm of armour at an incidence of 0° at a range of 1000 m.

The Tarasque is carried on a two-wheeled carriage that can be towed by a 4 × 4 light vehicle and takes only 15 seconds to bring into action. A normal crew would consist of three, one on the gun and two ammunition members.

The system can also be mounted in the rear of trucks such as TRM 2000.

### SPECIFICATIONS

<b>CALIBRE</b>	20 mm
<b>BARREL LENGTH</b>	2.065 m
<b>MUZZLE BRAKE</b>	yes
<b>OPERATION</b>	delayed blowback
<b>CARRIAGE</b>	2-wheeled
<b>SHIELD</b>	no
<b>WEIGHT</b>	
travelling order with ammunition	840 kg
firing position with ammunition	650 kg
<b>SWEPT RADIUS (at 0° elevation)</b>	2.4 m
<b>WIDTH (travelling)</b>	1.9 m



GIAT Industries Tarasque 53T2 20 mm automatic anti-aircraft gun in firing position (Pierre Touzin)



Renault TRM 2000 (4 × 4) truck which is used by the French Army to tow the GIAT Industries Tarasque 53T2 LAAG as well as carrying its crew and ammunition

TRACK	1.72 m
ELEVATION/DEPRESSION	+83°/-8°
TRAVERSE	360°
MAX LAYING SPEED (hydraulic)	
traverse	80°/s
elevation	40°/s
RATE OF FIRE (cyclic)	900 rpm
CREW	3 (1 on gun)
TOWING VEHICLE	Jeep type (4 × 4) truck

**Status:** Production complete but can be resumed if additional orders are placed. In service with France, Djibouti and Senegal.

**Manufacturer:** GIAT Industries, 13 route de la Minière, F-78034 Versailles Cedex, France.  
Telephone: (1) 30 97 37 37  
Fax: (1) 30 97 39 00

## GIAT Industries 53T1 Single 20 mm Light Anti-aircraft Gun

### Development/Description

Although produced in the 1960s, the 20 mm single-barrel 53T1 mount has been included because it has been seen with the French forces in Chad, in both the local air and ground defence roles.

The gun consists of four main parts: a three-trail carriage supporting a swivel and laying ring; a pivoting section with the gunner's seat, manual laying controls and the box magazine; an oscillating section with the gun cradle, ammunition supply chute and optical sight system and the hydraulically operated laying assembly with its motor.

The gun is normally used to defend infantry units and is drawn by a light vehicle or, if required, mounted on the rear of one.

### SPECIFICATIONS

CALIBRE	20 mm
CARRIAGE	2-wheeled with three outriggers
WEIGHT	
(in travelling order with ammunition)	635 kg
(in firing position with ammunition)	480 kg
LENGTH (travelling)	3.25 m
WIDTH (travelling)	1.76 m
HEIGHT (travelling)	1.60 m
ELEVATION/DEPRESSION	+83°/-3°
TRAVERSE	360°
FEED	200-round belt with disintegrating links
BASIC LOAD	400 rounds
CREW	2 (one on mount)
TOWING VEHICLE	4 × 4 vehicle

**Status:** Production complete. In service with the French Army.



GIAT Industries 53T1 single 20 mm light anti-aircraft gun deployed in Chad by French forces (ECP Armées)



Renault TRM 2000 (4 × 4) light truck towing GIAT Industries 53T1 single 20 mm light anti-aircraft gun system (Pierre Touzin)

## GERMANY

### KUKA 30 mm Arrow Anti-aircraft Gun

#### Development

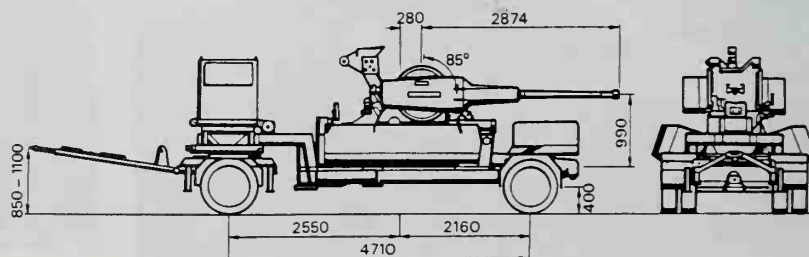
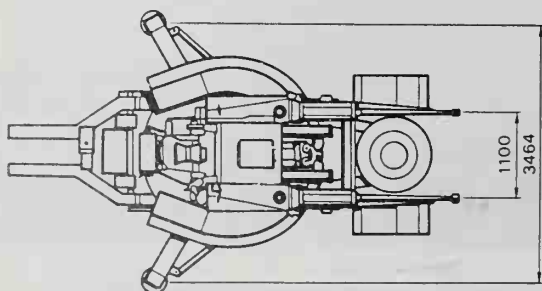
The twin 30 mm Arrow air defence system has been developed by KUKA Wehrtechnik GmbH to meet the requirements of the Royal Thai Air Force (RTAF). First production systems were delivered to Thailand in late 1988 and production is still underway.

The system is of modular construction enabling it to be tailored to meet the specific requirements of the user. The RTAF uses a single Contraves

Skyguard-M trailer-mounted fire control system to control two twin 30 mm Arrow systems. Other fire control systems can also be used with the Arrow system.

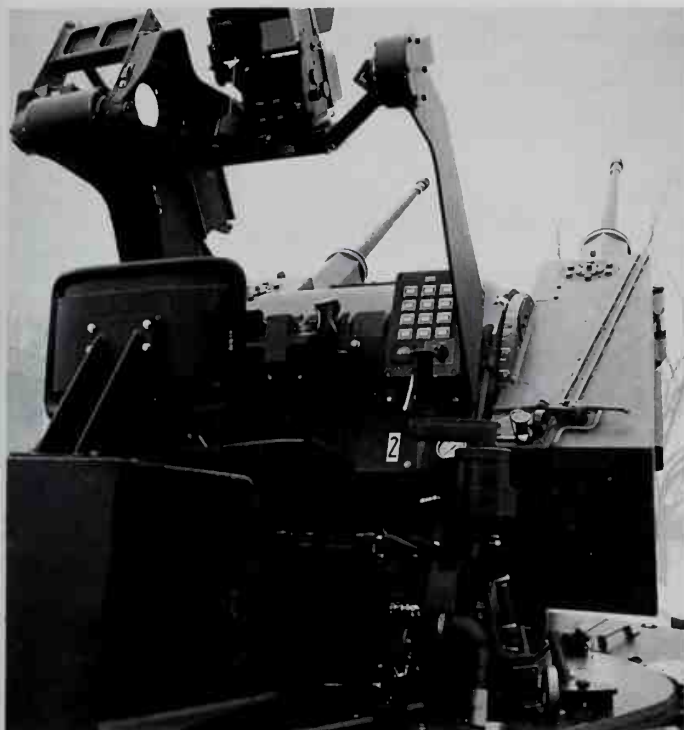
According to the manufacturer, the main advantages of the twin 30 mm Arrow air defence system can be summarised as short reaction time, good mobility, high fire power with cyclic rate of fire of 1600 rds/min, reduced manning and maintenance requirements.

The system has been designed to engage targets out to a maximum range of 3000 m.



Arrow twin 30 mm anti-aircraft gun system in firing position (left) and travelling position (right)





Close up of the gunner's position on the Arrow twin 30 mm air defence system

#### Description

In appearance, the twin 30 mm Arrow air defence system is similar to the first prototype of the Greek Artemis system which was developed by the same company (qv), but it does incorporate nine detailed improvements:

- (a) automatic levelling system
- (b) modified reload ammunition boxes
- (c) double support for the optical aiming device
- (d) integrated data unit
- (e) ability to wheel the cannon aside without removing the barrel
- (f) modified barrel guide bearing
- (g) twin tyres on the rear axle
- (h) spare parts stowed on the mount
- (i) improved performance of drive units.

A total of 500 rounds are carried for ready use. Traverse is electric of 360°, with elevation also electric from -5° to +85°. Horizontal levelling is accomplished automatically with a hydraulic device in combination with an electronic sensor package.

Three modes of operation are possible; fully automatic with input from fire control system, autonomous by the gunner using the joystick and optical sight and manual with elevation and traverse using handcranks. There are also three firing modes; electric from the fire control system, electric by actuating the fire trigger on the joystick and manual by mechanical foot pedal operation.

The system is provided with quick disconnect receptacles for data transmission, intercommunication and power supply.

An automatic levelling device enables the system to be quickly positioned into the horizontal position, it also performs automatic and accurate cant angle compensation. When in the firing position the mount rests on three outriggers so its centre of gravity is as low as possible.

To enable the system to be rapidly redeployed, it is based on a carriage with four dual rubber tyred road wheels. A three phase diesel generator is mounted on the front part of the carriage and when in the firing position this is detached and positioned away from the system. A slip ring transmitter attached on the bottom of the upper mount supplies the power and control signals that are required to turn and elevate the system.

Ammunition for the Mauser 30 mm cannon is stored in ammunition boxes left and right of the weapons and transferred to the weapons by an ammunition supply system. Each cannon is provided with 250 rounds of ready use ammunition.

The gunner's seat is mounted on a platform to the rear of the mount so that he can move with the traverse movement of the system. He aims the weapons using a joystick and an auxiliary sight.

The 30 mm Mauser cannon fire two main types of ammunition, the HEI/SD-T, which is used against aircraft, helicopters and ground targets



Twin 30 mm Arrow anti-aircraft gun system deployed in firing position and showing stabilisers extended

and the TP-T which is a low-cost traced training round ballistically matched to the HEI/SD-T projectile.

When used with a fire control system such as the Skyguard, a typical target engagement takes place as follows. The target is detected at a range of around 20 km and once acquired is tracked by the fire control sensor. A digital computer continuously calculates the lead values relative to the gun position, including meteorological data. Target information is relayed via a data transmission link to the guns.

Should there be a fault or if there is a threat of anti-radiation missiles, each mount is provided with an auxiliary sight to enable targets to be engaged visually.

#### SPECIFICATIONS

CALIBRE	30 mm
BARREL LENGTH (with muzzle brake)	3.35 m
TYPE	Mauser MK 30 mm Model F
RECOIL FORCE (max peak)	18 kN
RECOIL TRAVEL	45 mm
OPERATION	gas, automatic
CARRIAGE	4-wheel, cruciform
SHIELD	no
WEIGHT	6800 kg
LENGTH (travelling)	7.884 m
WIDTH (travelling)	2.38 m
WIDTH (firing)	3.464 m
GROUND CLEARANCE	0.40 m
WHEELBASE	4.71 m
ELEVATION/DEPRESSION	+85°/-5°
TRAVERSE	360°
LAYING RATE (traverse)	
remote	95°/s
autonomous	60°/s
LAYING RATE (elevation)	
remote	75°/s
autonomous	60°/s
RATE OF FIRE (cyclic)	1600 rpm
NUMBER OF ROUNDS (ready use)	500
TOWING SPEED	
road	80 km/h (max)
cross-country	30 km/h (max)

**Status:** In production. First deliveries to the Royal Thai Air Force were made in 1988.

**Manufacturers:** Mount: KUKA Wehrtechnik GmbH, Zugspitzstrasse 140, PO Box 43 12 80, D-8900 Augsburg 43, Federal Republic of Germany. Telephone: (0821) 797-1937 Fax: (0821) 797-1207

Cannon: Mauser Werke Oberndorf GmbH, D-7238 Oberndorf/Neckar, Teckstrasse 11, Federal Republic of Germany. Telephone: (07423) 701 Telex: 760301 Fax: (07423) 70238/70593

## Rheinmetall 20 mm AA Twin Gun Air Defence System

### Development

This anti-aircraft gun system has been developed by Rheinmetall under contract to the German Department for Ordnance Technology and Procurement. By 1991 over 1800 twin 20 mm systems have so far been delivered to German and other forces. The main advantages of the system are a high rate of fire, accurate laying of the guns by the computerised optical fire control system, large ammunition supply, rapid elevation and traverse due to hydraulic servo-drive, no requirement for an external power source, suitability for operations under a wide range of climates and a very short training time for operators.

### Description

The 20 mm AA twin gun air defence system consists of the following main components; two MK 20 Rh 202 cannon, ammunition supply, fire control equipment, laying mechanism, cradle, upper carriage, lower carriage and the two-wheeled trailer.

The 20 mm Rheinmetall MK 20 Rh 202 gas-operated and fully automatic cannon is also installed in the Marder IFV, Luchs 8 × 8 reconnaissance vehicle, FIAT/OTO Melara Type 6616 armoured car and the Norwegian 20 mm automatic anti-aircraft gun FK 20-2 which is described in this section. It is also used in the 20 mm naval mount designated the S20. The weapon has a low recoil force and can be stripped into the main assemblies without any tools. By means of the belt feeder Type 3, the cartridges can be fed selectively from two sides, the left gun from the left and above and the right gun from the right and above.

The ammunition feed comprises two ammunition boxes, two flexible belt clips and two belt-centring mechanisms. The two ammunition boxes are fixed to the upper carriage, one right and one left of the twin guns. Each box contains 270 rounds of ammunition and there are another 10 rounds in the feed mechanism. Flexible cartridge belt guide channels connect the ammunition boxes to the belt-centring devices, which centre the cartridges in the links of disintegrating belts and introduce belted ammunition to the feed mechanism.

The laying mechanism is mounted over the rear bearings of the upper carriage and carries the laying system. Maximum powered traverse speed is 80°/s and maximum powered elevation speed is 48°/s.

The weapons are fired by a foot-operated mechanism fitted with a safety device. An interlock, which can be overridden, stops the gun before the last round is fired. A selector lever enables the gunner to choose either single shots or sustained fire, with either electric or mechanical firing from one or both barrels. The following types of fixed (20 mm × 139) ammunition can be fired:

AMMUNITION TYPE	APDS-T	API-T	HEI	HEI-T	TP/TP-T	Break Up
GERMAN DESIGNATION	DM63	DM43A1	n/app	DM51A2 DM81	DM48 DM48A1 DM98	DM78A1
WEIGHT OF PROJECTILE	108 g	111 g	120 g	120 g	120 g	120 g
MUZZLE VELOCITY	1250 m/s	1100 m/s	1050 m/s	1050 m/s	1050 m/s	1050 m/s



*Rheinmetall 20 mm AA twin gun air defence system in travelling order*

The Italian Galileo P56 computing sight (to be replaced by the P75 fire control system with a laser rangefinder) has the following main components: monocular optical sight with a magnification of × 5 and a 12° field-of-view with a swivelling objective prism for laying the gun against air and ground targets; electronic analogue computer for calculating lead values; joystick with 2° of freedom for the speed control of the line-of-sight; input panel for target speed and crossing point distance of air targets and target distance of ground targets.

The cradle is made of light alloy and its trunnions engage in the trunnion bearings of the upper carriage and rotate the cradle in elevation. During firing the cradle acts as the recoil bed of the guns. At the forward end of the cradle are two hinged covers to enable the weapons to be removed and at the top it is closed by two lockable hinged frames which also hold the belt feed mechanisms and the ejectors. The trigger mechanism and the cocking device are also housed on the cradle.

The upper carriage is also made of light metal with the laying mechanism fitted to the sidewalls. It also carries the gunner's seat and at the top of the upper carriage are the trunnion bearings in which the cradle fits. The centre of gravity of the cradle system, when fitted with the cannon, is off-centre, with static weight equilibrium achieved by two balancers. Two multi-stage



*Rheinmetall 20 mm AA twin gun air defence system deployed in firing position*



*Rheinmetall 20 mm AA twin gun air defence system in firing position*



elevating gears are flanged to the cheeks of the upper carriage. On the left side of the upper carriage is the firing pedal and the hand lever for locking the guns is on the right.

The lower carriage has three outriggers, two of which are adjustable for levelling. On the lower carriage is a brake lever for locking the upper carriage and at the end of each outrigger is a socket for securing the mounting on the trailer.

The two-wheeled trailer is used to transport the mounting with the lower carriage secured to the trailer by a swivel ring at the front and two lockable devices at the rear. The towing bracket of the trailer is adjustable to fit the height of the coupling of the vehicle and couplings and wiring for 12 or 24 V lighting are standard. When the mounting is put on or taken off the trailer, the wheels are secured by wedges, this being the only task which requires three men.

Optional equipment includes a Taboo facility which can be programmed by the gunner to prevent the guns firing at specific objects, laying exercise kit S11 for the simulation of programmed flight paths with the sight for training purposes, video training system and radio equipment to link the gun with the battery commander or command post.

The French Air Force uses an identical mount fitted with French GIAT Industries 20 mm M693(F2) cannon under the designation 76T2, or Cerbere. A description of this model is given in the French section.

#### Variants

There is a separate entry under International in the *Self-Propelled Anti-Aircraft Guns* section for this system on a British Hotspur 6 × 6 modified Land Rover chassis.

#### SPECIFICATIONS

CALIBRE	20 mm × 139
GUNS	2 × MK 20 Rh 202
BARREL LENGTH (including muzzle brake)	2.61 m
OPERATION	gas, automatic
CARRIAGE	2-wheeled with outriggers
SHIELD	armoured
WEIGHT	
in travelling order without ammunition	2160 kg

in firing position with ammunition	1640 kg
SWEPT RADIUS (at 0° elevation)	2.62 m
LENGTH	
travelling	5.035 m
firing	4.05 m
WIDTH	
travelling	2.36 m
firing	2.3 m
HEIGHT	
travelling	2.075 m
firing	1.67 m
AXIS OF BORE (firing)	0.735 m
ELEVATION/DEPRESSION	
powered	+81.6°/-3.5°
manual	+83.5°/-5.5°
TRAVERSE	360°
RATE OF FIRE PER BARREL (cyclic)	1000 rpm
EFFECTIVE ANTI-AIRCRAFT RANGE	2000 m
CREW	3 or 4 (1 on mount)
TOWING VEHICLE	4 × 4 truck

**Status:** Production as required. In service with the following countries:

Country	Quantity	User	Comment
Argentina	30+	air force	used with Elta early warning radar. Army may also use 30+ systems
Germany	1670	air force	
Greece	200	all forces	
Indonesia	9	army	
Portugal	36	army	

**Manufacturer:** Rheinmetall GmbH, Ulmenstrasse 125, D-4000 Düsseldorf, Federal Republic of Germany.  
Telephone: (0211) 44701  
Telex: 85833-0  
Fax: (0211) 483290

## GREECE

### Hellenic Arms Industry Artemis 30 mm Light Anti-aircraft Gun System

#### Development

The Artemis twin 30 mm air defence system has been designed by the Hellenic Arms Industry SA to meet the requirements of the Greek Army and was shown in public for the first time during the Defendory Exposition held in Athens in October 1982.

The carriage was designed in collaboration with the German company of KUKA GmbH while the twin 30 mm cannon and its associated ammunition come from Mauser, also of Germany. The fire control system and the battery co-ordination post with the acquisition radar system which are employed in the Artemis 30 were jointly developed by Bofors, Siemens and EBO respectively.

In June 1983 it was announced that negotiations on a production contract for deliveries over a five year period were being conducted with the Greek Ministry of Defence and the contract was signed in October 1984. The first two Artemis 30 mm light anti-aircraft guns were completed in early 1988.

The current system configuration is one battery co-ordination post, two fire control systems and eight twin cannon carriages.

#### Description

The Artemis 30 fire unit is a twin 30 mm cannon system towed on a twin-axled split-type carriage. The axle nearest the towing arm carries the generator which powers the cannon system in action. When deployed this axle/generator assembly is removed and placed some distance away from the mount. The deployed mount is lowered and levelled by means of three hydraulically operated pads, two on outrigger arms, while the rear axle is power-retracted upwards.

The weapons are mounted on each side of a horizontal drum assembly which elevates the cannon. This assembly is placed on a central support on a turntable effecting the weapon traverse movement. The circular ammunition hoppers holding 500 linked rounds (250 for each cannon) are also on the central support. Each cannon receiver has a protective housing which covers the cannon to the base of the barrel. Each of these boxes can be opened to reveal the mechanism to clear jams or for routine servicing. By removing the gun barrel, the receivers can be swung outwards for more involved repairs and maintenance. The linked ammunition is fed from the

hoppers upward through the central drum and into the feeders from the inside. Spent links and cases are ejected through slots in the cannon housings.

The weapons are the Mauser 30 mm MK 30 Model F cannon, with EBO-produced cold-forged barrels with a constant rifling pitch. The



Artemis 30 battery co-ordination post with radar in position



*Artemis 30 in travelling configuration*

twin-cannon upper mount assembly has an unlimited  $360^\circ$  arc in traverse, while the elevation arc is from  $-5^\circ$  to  $+85^\circ$ .

The mount has three distinct modes of operation:

- (1) operation via a remote fire control system
- (2) operation via a gunner seated directly behind the central mount support. In this mode the gunner is supplied with all necessary controls including a periscope for ground targets and a gyroscopic angle predicting sight for air target engagement
- (3) emergency operation via the gunner (no power supplied to the mount).

Weapon aiming is accomplished via hand wheels, firing via a foot trigger.

The weapons use the well-known 30 mm  $\times$  173 Artemis family of ammunition including HEI-SD, HEI-T-SD, TP and TP-T.

It was established early on that Artemis 30 would not be fully dependent on radar fire control. However, it was decided that any fire control method would be of modular form to encompass radar when required.

Bofors Electronics delivered the first production systems early in 1988 with deliveries expected to continue through to the late 1990s.

The fire control system consists of tracking sensors mounted on a two-wheeled trailer with the tracking sensors consisting of a frequency agile J-band radar and a TV camera with auto-tracker and laser rangefinder.

The battery co-ordination post and acquisition radar system was developed by Siemens of Germany who handed over the first system to Greece in July 1988. This system is shelter-mounted and consists of a roof-mounted pulse Doppler radar system for surveillance and target acquisition, secondary radar for IFF, command and control computer display, and communications equipment.

It processes all incoming data and transmits information to the fire control systems, provides information to a total of 12 fire control systems and is capable of tracking up to 20 targets simultaneously.

A fire control centre controls four guns spread over an area about the size of an airfield with each gun operating over a range of 3500 m.

Being modular, the Artemis 30 fire control system can be expanded and adapted to suit the operational requirement. For use at night the fire control director can be reconfigured with an infra-red sensor. The system can also be adapted to hand missile launchers.

#### Variants

The company has proposed that this system could be mounted on the chassis of the Steyr 4K 7FA armoured personnel carrier which is already being manufactured under licence in Greece for the Greek Army.



*Artemis 30 deployed in firing position*



*Artemis 30 fire control system deployed in the field*



**SPECIFICATIONS**

CALIBRE	30 mm
BARREL LENGTH (with muzzle brake)	3.35 m
OPERATION	gas, automatic
CARRIAGE	4-wheel, cruciform
SHIELD	no
WEIGHT	
travelling (without ammunition)	6900 kg
travelling (with ammunition)	7400 kg
firing (with ammunition)	5900 kg
LENGTH (travelling)	8.02 m
WIDTH (travelling)	2.38 m
HEIGHT (travelling)	2.48 m
TRACK	1.8 m
WHEELBASE	4.35 m
GROUND CLEARANCE	0.30 m
ELEVATION/DEPRESSION	+85°/-5° at 75°/s
ELEVATION ACCELERATION	150°/s <sup>2</sup>

TRAVERSE	360° at 100°/s
TRAVERSE ACCELERATION	200°/s <sup>2</sup>
RATE OF FIRE	
(both guns)	1600 rpm
NUMBER OF ROUNDS	
(ready use)	500
OVERALL CARRIAGE	
ACCURACY	less than 1.5 mrad
MAX TOWING SPEED	80 km/h

**Status:** In production for Greek Army, Navy and Air Force.

**Manufacturer:** Hellenic Arms Industry SA, 160 Kifissias Avenue, Athens, Greece.

Telephone: 647 2611 16

Telex: 21 8562 EBO GR

Fax: 647 2715

## HUNGARY

### 57 mm Automatic Anti-aircraft Gun SZ-60

**Development/Description**

This is essentially the Soviet 57 mm automatic anti-aircraft gun S-60, fully described later in this section, manufactured under licence in Hungary for both the home and export markets. Although the SZ-60 is similar to the Soviet S-60, there appear to be some differences between the two weapons and the information in the specification table is from Hungarian sources and issued early in 1991.

There is however a possibility that these weapons are being offered on the export market, as with the reduction in size of the Hungarian Army considerable quantities of equipment are now becoming surplus to requirements.

According to the Hungarians, SZ-60 is used in conjunction with gun laying radar and a fire control director to engage aerial targets flying at a maximum altitude of 6000 m, or 5500 m using the onboard sighting system.

The SZ-60 57 mm anti-aircraft gun system has three methods of operation, fully automatic using the off carriage fire control system, semi-automatic and manual. When in the fully automatic mode, elevation and traverse is powered with manual controls being provided for back up. The Hungarians also state that the barrel has a cooling system to enable a high rate of fire to be maintained.

**SPECIFICATIONS**

CALIBRE	57 mm
MUZZLE BRAKE	multi-perforated
METHOD OF OPERATION	recoil, full automatic
CARRIAGE	4-wheel
SHIELD	yes

WEIGHT	
travelling order	4950 kg
AXIS OF FIRE	1.03 m
ELEVATION/DEPRESSION	
manual	+87°/-2°
powered	+87°/0°
TRAVERSE	360°
MAX POWERED	
traverse	30°/s
MAX POWERED	
elevation speed	18°/s
RATE OF FIRE	
CYCLIC	100-120 rpm
practical	70 rpm
FEED	4-round clip
MUZZLE VELOCITY	1000 m/s
WEIGHT	
complete round	6.61 kg
MAX RANGE	
vertical	8800 m
MAX RANGE	
horizontal	12 000 m
MAX TARGET	
speed	300 m/s
CREW	5

**Status:** Production as required. In service with Hungarian Army and available for export.

**Manufacturer:** Hungarian state factories.

## INDIA

### Bofors 40 mm L/70 Anti-aircraft Gun

**Development/Description**

For many years the Indian Gun Carriage Factory at Jabalpur has been manufacturing the Bofors 40 mm L/70 anti-aircraft gun under licence.

Full details of this weapon are given in this section under Sweden. The Indian production version can be operated in three modes; manually by two people, by remote-control with an off carriage fire control system such as Super Fledermaus or the more recent Flycatcher which is now being made under licence in India, or local power control using a joystick.

It is normally deployed in action using extended stabilisers and four jacks, but in an emergency it can be fired with these deployed for travelling.

Firing limiting gear has been fitted in both elevation and traverse to prevent firing within a safety zone when the weapon is power-operated.

**SPECIFICATIONS**

CALIBRE	40 mm
WEIGHT	
travelling	4700 kg
firing	3850 kg (axles detached)

ELEVATION/DEPRESSION	+90°/-5°
TRAVERSE	360°
MAX ELEVATION SPEED	45°/s (powered)
MAX TRAVERSE SPEED	85°/s (powered)
RATE OF FIRE (cyclic)	240 rpm
MAX HORIZONTAL RANGE	12 600 m
WEIGHT OF COMPLETE ROUND	2.5 kg
TIME OF SELF DESTRUCTION	
OF PROJECTILE	8 s
TOWING VEHICLE	3 t (4 × 4) truck

**Status:** Production complete but can be resumed if required. In service with Indian armed forces.

**Manufacturer:** Gun Carriage Factory, Jabalpur 482 001, India.

Enquiries to: The Secretary, Ordnance Factory Board, 10/A Aukland Road, Calcutta 700 001, India.

## ISRAEL

## RAMTA Structures and Systems TCM Mk 3 Light Air Defence Artillery System

### Development

Based on its experience in the design, development and production of the TCM-20 twin 20 mm anti-aircraft system (fully described in the following entry), RAMTA Structures and Systems has now developed the TCM Mk 3 light air defence artillery system. It was first announced in 1983 and was said to be in production and service in 1984.

### Description

The mount is similar to the earlier TCM-20s but has been fitted with advanced systems and subassemblies, such as new drives, and has a more modern sight. The system can also be integrated with a fire control system manufactured by the MBT Electronics division of Israel Aircraft Industries which is based on a computerised sight and system integrated laser rangefinder. Using suitable adaptors the TCM Mk 3 can accept most 20 to 25 mm light guns, the self-propelled model shown in the photograph being fitted with the Soviet 23 mm ZU-23 cannon. In addition the system can be installed on naval craft as main and secondary armament.

Command and control of the TCM Mk 3 mount is through a variable speed joystick system. Mechanical movement of the joystick by the gunner



TCM Mk 3 system fitted with 23 mm ZU-23 cannon

at the rear of the mount is converted to an electrical signal which passes to servo-amplifiers to convert it through acceleration cards into a command for the motors. The firing lock is on the joystick so the gunner does not have to move his hand to release the lock and open fire.

The new drive system consists of two separate and similar units, traverse and elevation. Each unit includes a 24 V servo-motor, servo-amplifier, torque limiter, gear and feedback system. The drive system is very sensitive to joystick commands so the gunner can track fast and slow targets.

The bearing system consists of three sealed, maintenance free bearings, two for elevation and one for traverse. Their crosswire structure minimises backlash and increases firing accuracy. The elevation bearings have gear selectors and the traverse bearing has a ring gear.

### SPECIFICATIONS

CALIBRE	20 to 25 mm (eg 20 mm HS 404, HS 804, HS 820, Rh 202 and F623)
CARRIAGE	towed or self-propelled
SHIELD	yes
WEIGHT	1350 kg (towed model with HS 404 guns)
ELEVATION/DEPRESSION	
mechanical	+90°/-10°
electrical	+85°/-6°
TRAVERSE	360° (0.25°/s to 75.0°/s max)
ELECTRICAL POWER	24 V DC
MAIN POWER SOURCE	2 × 12 V, 80 Ah batteries
AUXILIARY POWER SOURCE	28 V DC, 3.75 hp petrol engine generator
SIGHTS	
standard	M18 optical
optional	× 4 Starlight system for night operation, MBT fire control system including computerised sight and system integrated laser rangefinder

**Status:** Production as required. In service with the Israel Defence Force Air Force.

**Manufacturer:** RAMTA Structures and Systems, PO Box 323, Beer Sheba, Israel (a Division of Israel Aircraft Industries Limited).

Telephone: (057) 74851/3

Telex: 5298 IAIBS IL

## RAMTA Structures and Systems TCM-20 Twin 20 mm Anti-aircraft Gun System

### Development

The TCM-20 twin 20 mm anti-aircraft gun system was developed by the MBT Division of Israel Aircraft Industries from 1969 to meet the requirements of the Israeli Defence Air Force. It was first used in 1970 during the War of Attrition when it was credited with shooting down 10 aircraft in 10 engagements. During the Yom Kippur War it is credited with shooting down 60 per cent of the aircraft downed by ground air defences.

By March 1983 the company had built a total of 700 TCM-20 twin 20 mm anti-aircraft systems which had been delivered to Israel and seven other countries. Since then production has continued to meet export requirements although no recent production figures have been released.

In the 1982 Lebanon campaign the TCM-20 was used in three roles, against ground forces in urban areas, against aircraft and helicopters and against ground forces in the field as a close support weapon.

Israel uses the TCM-20 in two models, towed and self-propelled. The latter is basically the standard towed model mounted on the rear of a half-track; it crossed the Suez Canal with the Israeli spearhead. It was used to defend convoys and bridgeheads and also proved effective in urban fighting.

It has been installed on the RAMTA Structures and Systems RAM (4 × 4) light armoured vehicle. This version is supplied with two hydraulic jacks to provide a more stable firing platform. For trials purposes this turret has been installed on a Chinese 6 × 6 licence built MOWAG Piranha armoured personnel carrier chassis.

The TCM-20 can also be used in conjunction with the EL/M 2106 point defence alert radar.

### Description

The TCM-20 is essentially a modernised version of the American M55 trailer-mounted anti-aircraft gun system with the original four Browning

12.7 mm (0.50) M2 HB machine guns replaced by two Hispano-Suiza HS 404 20 mm cannon modified to fire HS 804 ammunition which includes HEIT-SD, HEI, APT and TP-T.

Main components of the TCM-20 are the carriage, mount, APU, two 12 V batteries with a capacity of 80 Ah, two 20 mm cannon and an M18 reflex sight.

The gunner has front and side armour protection. If required elevation and traverse limiters can be installed. No external power source is required as all the drive and firing systems are electric and the APU maintains the charge levels of each of the standard 12 V batteries. Turret traverse and gun elevation speeds are 60 to 72°/s in azimuth and 60 to 67°/s in elevation.

The cannon are cocked manually and fired by an electrically driven solenoid which is controlled by redundant triggers in the gunner's control



TCM-20 twin 20 mm anti-aircraft gun system installed on Israeli half-track



handle. Each of the 20 mm cannon has a 60-round drum type magazine which weighs 12 kg empty and 28 kg loaded.

The towed version can be carried slung under a Bell 205 helicopter while a CH-53 helicopter can carry a Jeep and a TCM-20. The TCM-20 can be uncoupled from its towing vehicle and be ready for action in less than 40 seconds. In the firing position the carriage is supported on three jacks, one at the front of the carriage to the rear of the towing eye and the other two at the rear of the carriage.

#### SPECIFICATIONS

CALIBRE	20 mm
OPERATION	blowback with positive breech locking
CARRIAGE	2-wheeled
SHIELD	yes
WEIGHT (travelling order)	1350 kg (with two loaded magazines)
LENGTH (travelling)	3.27 m
WIDTH (travelling)	1.7 m
HEIGHT (travelling)	1.63 m
GROUND CLEARANCE (travelling)	0.31 m
TYRES	7.00 × 16
ELEVATION/DEPRESSION	+90°/-10°
TRAVERSE	360°
RATE OF FIRE PER BARREL	
cyclic	600/700 rpm
practical	150 rpm
MAX RANGE	
horizontal	5700 m
vertical	4500 m
EFFECTIVE RANGE	
aircraft targets	1200 m
ground targets	1500 m
TOWING VEHICLE	Jeep type (4 × 4) truck

**Status:** Production as required. In service with at least seven countries including:

Country	Quantity	User	Comment
Argentina	24+	air force	uses Elta radar, towed version only
Haiti	6	army	towed version only
Israel	370	air force	uses Elta radar, both towed and self-propelled systems used, total is for both types
Kenya	50	army	towed version only

**Manufacturer:** RAMTA Structures and Systems, PO Box 323, Beer Sheba, Israel. (A division of Israel Aircraft Industries Limited.)  
Telephone: (057) 74851/3  
Telex: 5298 IAIBS IL



TCM-20 twin 20 mm anti-aircraft gun system in firing position with jacks lowered

## ITALY

### Breda Twin 40L70 Field Mounting

#### Development

Breda Meccanica Bresciana has produced a field mounting version of its well-established twin 40 mm naval anti-aircraft gun for use against low-flying aircraft and missile targets. The gun is fully automatic and no one needs to be on the mounting when it is in action. It can be used in conjunction with a wide range of fire control systems such as the Hollandse Signaalapparaten Flycatcher. The combination of two Breda Twin 40L70s and a Signaalapparaten Flycatcher is marketed as a low level air defence system known as Guardian. A total of 36 mounts were acquired by Venezuela in the early 1980s as part of a Guardian system. These are operated by the Army.

Typical roles of the Guardian air defence system, according to Breda, include the protection of high value targets in the rear area including airfields, missile sites, ammunition storage areas, headquarters and high value civilian targets of strategic importance such as oilfields.

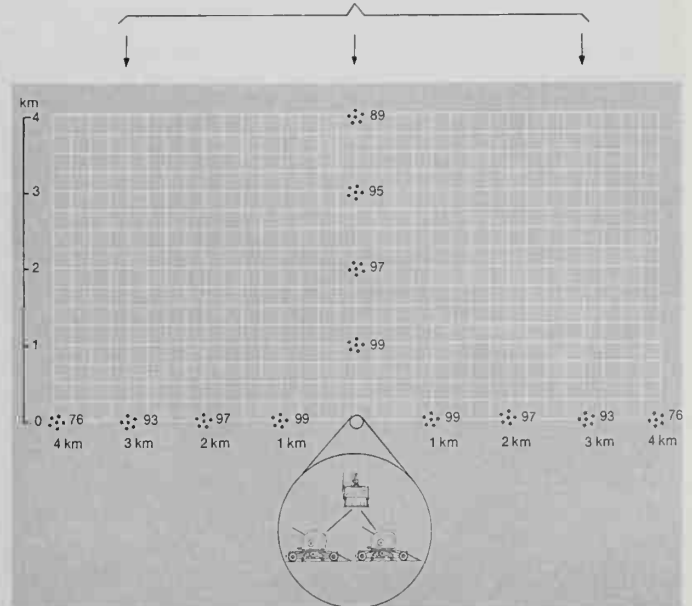
During trials at the Italian School of Anti-aircraft Artillery, inert rounds were fired against a towed sleeve target. A total of 218 rounds were fired of which 78 per cent (171 rounds) fell within 4 m of the target and a further 12.9 per cent (28 rounds) fell within 8 m. Using proximity fuzes ammunition the sleeve target was shot down in all cases with the first rounds of the burst.

#### Description

The guns used with the Breda Twin 40L70 are two Bofors 40 mm L/70 guns joined together to form a twin elevating mass by a specially designed twin cradle. The barrels are set 30 cm apart to reduce the elevating mass recoil forces and to reduce weight. Each gun is a standard Bofors 40 mm L/70.

The field mounting consists of a 360° traverse training platform supported on a wire race bearing. The platform has parallel vertical lightweight aluminium alloy trunnion supports, it also holds the servo and ammunition feed motors, together with the upper ammunition feed mechanism, firing

TRAJECTORY OF THE TARGET



*Effectiveness of the Guardian air defence system showing kill probability of two gun systems used with Flycatcher fire control system against a fighter bomber flying on a straight course at an altitude of 50 m at a speed of 300 m/s or over, with the 40 mm cannon using pre-fragmented ammunition fitted with a proximity fuze*



*Breda Twin 40L70 Field Mounting deployed in firing position with Flycatcher fire control system in right background*

mechanism and system junction box. The upper section of the mounting is completely enclosed in a watertight reinforced glass fibre cupola fitted with three servicing hatches, one at the rear and one on each side.

Under the mounting platform inside the carriage is the magazine. The carriage is normally carried on four wheels and two axles. To get the gun into action the carriage is emplaced in the firing position and levelled using six outrigger jacks; one each at the front and rear and the four others on outrigger arms which are swivelled outwards. Once emplaced pickets are driven into the ground from the outrigger feet, and connections to the gun from external generator and fire control system are made via junction boxes. The external generator supplies 440 volts AC at a frequency of 60 Hz. Hatches on each side of the lower carriage give access to the ammunition magazine.

Rounds are fed into the magazine from four-round clips. The magazine consists of four horizontal layers equipped with a system of inner moving bands and ratchets that propel the rounds towards the ammunition hoisting chains. The system is divided into two independent sections, each of which delivers ammunition to one of the guns. The magazine trains with the mounting, and the supply system is arranged so that if one gun is out of action the other can continue to fire. The forward section of the magazine supplies the left-hand gun and the rear section supplies the right-hand gun. The system is driven by a 400 V, 60 Hz motor which supplies either fast or slow drive. The slow drive operates the magazine conveyors and the scuttle transferring the rounds to the lower chain hoist. The fast drive operates at speeds in excess of 300 rpm to drive the ammunition chain hoists and the scuttle at the top of the hoist. From this top scuttle the fast drive also feeds the rounds into fan-shaped shifters which move the rounds through 90° into the gun feeders. Empty cases are ejected down a chute to the front of the gun. The chain hoists take four rounds from the magazine

every 0.7 seconds. A series of brakes and slipping clutches detect any misfeeds. Rounds are fed into the lower magazine manually via the side hatches and when fully loaded each mounting can hold 444 rounds.

The gun is trained by electrical DC motors driving epicyclic gearboxes. The gearboxes have a coarse synchro ratio of 1:1 and a fine rate of 1:36 but this fine rate may be varied to suit individual systems.

The interior of the watertight cupola is supplied with forced ventilation. The Breda Twin 40L70 Field Mounting can accommodate all the many forms of Bofors 40 mm ammunition, including proximity fuzed rounds.

The twin mounting can supply a rate of fire of 600 rds/min, but variations may occur depending on the type of ammunition used.

#### Variant

Future Breda Twin 40L70 Field Guns will be fitted with a new Breda recoiling mass called the Fast Forty which enables the system to have a cyclic rate of fire of 450 rounds per barrel per minute.

Digital control is also fitted which allows easy and fast introduction of prohibited zones by means of a keyboard; rapid alignment of the gun and fire control system; automatic correction of line-of-fire in relation to platform inclination; visualisation of diagnostic messages on the local control panel and control of the gun by means of serial transmission of gun orders through a two wire cable.

The dramatic increase in performance has been aided by wide adoption of materials such as titanium which is characterised by high resistance. The new design entailed a sweeping reduction of the distance run by moving



*Twin 40L70 Field Mounting in travelling configuration with outriggers and stabilisers retracted*



*Twin 40L70 Field Mounting deployed in the firing position and firing twin 40 mm L/70 guns*



components with a consequent saving in time. Valuable milliseconds have been gained, for example, by greatly reducing the recoil length and in addition a new conception ramming device has been introduced which allows the transfer of the round direct from the feeding position to the breech-block closing position, taking a shorter route analogous to the hypotenuse of a triangle instead of following the two sides as in the current 40L70 weapon.

Energy made available in firing, accumulated in hydro-pneumatic linear motors in the return in battery phase, affords faster and better controlled breech operation allowing optimisation of the requisite acceleration and deceleration. These devices are employed, for example, for return in battery of the recoiling mass, moving the ramming device and decelerating the round immediately before breech-block closing, thus accumulating energy employed to render faster the upward movement of the block.

#### SPECIFICATIONS

CALIBRE	40 mm
BARREL LENGTH	2.8 m
RECOIL MECHANISM	hydro-spring
BREECH MECHANISM	vertical sliding
CARRIAGE	4-wheeled with 6 outriggers
SHIELD	glass fibre cupola
WEIGHT OF TRAINING MASS (without ammunition)	5350 kg
TOTAL WEIGHT (without ammunition)	10 400 kg
WEIGHT OF AMMUNITION	1100 kg
LENGTH (travelling)	8.2 m
WIDTH (travelling)	3.155 m

HEIGHT (travelling)	3.47 m approx
GROUND CLEARANCE (travelling)	0.3 m approx
TRACK	2.5 m
WHEELBASE	5 m
RECOIL FORCE (average per barrel)	2700 kg
TRAINING VELOCITY	90°/s
TRAINING ACCELERATION	120°/s <sup>2</sup>
TRAVERSE	360°
ELEVATION VELOCITY	60°/s
ELEVATION/ ACCELERATION	120°/s <sup>2</sup>
MAGAZINE CAPACITY	444 rounds
RATE OF FIRE (both barrels)	600 rpm approx
MAX RANGE vertical	8700 m
horizontal	12 500 m
AMMUNITION FEED RATE	330 rounds per barrel per minute (the Fast Forty version has a cyclic rate of fire of 450 rounds per barrel per minute)
TOWING VEHICLE (typical)	FIAT 6605 (6 × 6) truck

**Status:** Production as required. In service with Venezuela (36 Army).

**Manufacturer:** Breda Meccanica Bresciana SpA, 2 Via Lunga, I-25128 Brescia, Italy.  
Telephone: (030) 31911  
Telex: 300056 BREDAR I

## Breda 40 mm Anti-aircraft Gun

#### Development/Description

Breda Meccanica Bresciana has manufactured the Swedish Bofors 40 mm L/70 anti-aircraft gun under licence as well as a number of naval mounts of both its own and Swedish Bofors design. The first Breda 40 mm guns were produced for the Italian Army in 1969.

Breda has also developed an Automatic Feeding Device (AFD) which can be fitted to single versions of the 40 mm L/70 anti-aircraft gun, as well as naval weapons of this calibre. The AFD can be provided by Breda in kit form, installed on new production guns or fitted when the guns are returned to Breda for overhaul.

The conversion consists of substituting parts of the elevating mass to increase the cyclic rate of fire from 240 to 300 rds/min, where this has not already been done, and installing the ammunition feeding complex on the

platform. The performance of the gun is not affected by the modification and loading and firing rates remain constant through all the elevation range. All types of ammunition can be fired including proximity fuzed ammunition. Main advantages of the system are the higher rates of fire and the reduced manning requirements as only two men are required on the mount when the optical fire control system is being used.

Loading is simple and quick and only one loader is required. The magazine, which comprises three layers, rests on the traversing platform and four-round clips of 40 mm ammunition are fed into the magazines via prepared ramps. The magazine holds 144 rounds of ammunition.

When firing, the rounds are automatically fed along the layer and taken up in threes by the elevation chain to a fan-shaped shifter at trunnion axis level, which through differentials adjusts to barrel elevation and conveys the rounds to the feeder. The power to carry out this operation is provided by an electric motor. A 32-round feeder called the AL-100 is also available from Breda.



Breda 40 mm L/70 anti-aircraft gun with automatic feeding device in travelling order



*Breda-built 40 mm L/70 anti-aircraft gun in firing position with automatic feeding device on rear part of traversing platform*

#### SPECIFICATIONS

(where different from Swedish  
40 mm Bofors L/70)

WEIGHT (travelling order)	5300 kg
LENGTH (travelling)	7.28 m
WIDTH (travelling)	2.289 m
HEIGHT (travelling)	2.655 m
AXIS OF BORE (travelling)	1.735 m
TRACK	
front	1.77 m
rear	1.796 m
WHEELBASE	4.025 m
ELEVATION/DEPRESSION	+85°/-5°
TRAVERSE	360°
TRAVERSE SPEED	85°/s
ELEVATION SPEED	45°/s
RATE OF FIRE (cyclic)	300 rpm
CREW	2 (on mount)

**Status:** Production as required. It is understood that 200 40 mm L/70 guns were built for the Italian Army and 50 for the Greek Army.

**Manufacturer:** Breda Meccanica Bresciana SpA, 2 Via Lunga, I-25128 Brescia, Italy.

Telephone: (030) 31911

Telex: 300056 BREDAR I

## Breda Sentinel Twin 30 mm Anti-aircraft Gun

### Development/Description

The Breda Twin 30 mm anti-aircraft gun uses two 30 mm Mauser Model F guns mounted side by side on a mobile field mounting. The Twin 30 mm is intended to operate as an independent unit and has its own power source and optronic fire control unit.

On tow the Twin 30 mm has its barrels pointing to the rear and is carried on a pair of two-wheeled axles. To bring the weapon into action the wheels are raised on swivels until they are clear of the ground, the gun is then supported on four levelling jacks, one each at the front and rear and the two side jacks on outward-folding outrigger arms. The guns traverse with the mounting on a turntable with the aimer, who is provided with a shield, seated to the left of the barrels. The second prototype has hydraulic wheel-drives for limited self-propulsion, an automatic outrigger extension and levelling and optronic improvements. Other improvements include a new gunner's position, new type shield and a different generator at carriage rear.

The aimer is provided with an Officine Galileo model P75D optronic fire control system. This comprises control panel, a laser rangefinder, an optical aiming device and a computer combined in one unit. To track a target the target line-of-sight is held by operating the system joystick to enable the lead angle to be automatically applied to the guns while at the same time the laser rangefinder also provides fire data. Passive infra-red night aiming equipment is optional and at all times target acquisition data from external sources such as radar may be fed into the system.

Power for the mounting and the fire control system is provided by a power supply unit carried over the rear axle. The main power source is a HATZ 3L 40C four-stroke diesel engine. This air-cooled engine has three cylinders and a capacity of 2.5 litres. Using a direct injection system the engine has a maximum speed of 3000 rpm. Electrical power is supplied by SACCARDO GS 132 M/16 three phase brushless alternators.

The two 30 mm Mauser Model F guns are mounted side by side and are provided with 500 rounds of ammunition. Each barrel has a rate of fire of 800 rds/min (cyclic) and the ammunition feed uses belt guides to move the rounds to the guns. The ammunition used is of the GAU-8/A type and includes APDS, HEI, API, HEI-SD and TP with a maximum muzzle velocity of 1040 m/s.

### Variants

## Breda Sentinel Twin 25 mm Anti-aircraft Gun

This weapon is basically the Breda Sentinel system with the two 30 mm Mauser cannon replaced by two Oerlikon-Contraves 25 mm KBB weapons.

### SPECIFICATIONS

CALIBRE	30 mm
BARREL LENGTH	2.458 m
CARRIAGE	4-wheeled with two outriggers
SHIELD	yes
WEIGHT	
(with ammunition)	5000 kg
LENGTH (travelling)	6.46 m
WIDTH (travelling)	1.76 m
HEIGHT (travelling)	1.94 m
GROUND CLEARANCE	0.43 m
TRACK	1.76 m
WHEELBASE	3.5 m
ELEVATION/DEPRESSION	+85°/-5°



*Second prototype of the Breda Sentinel twin 30 mm anti-aircraft gun system which has a hydraulic road wheel-drive system*



*Second prototype Breda Sentinel twin 30 mm anti-aircraft gun in travelling configuration and showing APU on rear of carriage*



ELEVATION SPEED	80°/s
ELEVATION	
ACCELERATION	120°/s <sup>2</sup>
TRAVERSE	360° at 120°/s
TRAVERSE ACCELERATION	150°/s <sup>2</sup>
FLIGHT TIME TO 3000 m	5.2 s
RATE OF FIRE (combined)	1600 rpm
MUZZLE VELOCITY	1040 m/s
AMMUNITION CAPACITY	500 rounds

**Status:** Development complete. Ready for production.

**Manufacturer:** Breda Meccanica Bresciana SpA, 2 Via Lunga, I-25128 Brescia, Italy.  
Telephone: (030) 31911  
Telex: 300056 BREDAR I

## Breda/Oerlikon-Contraves Vigilant Twin 25 mm KBA Anti-aircraft Gun

### Development/Description

The Vigilant twin 25 mm towed anti-aircraft gun system is a private venture development between Breda and Oerlikon-Contraves. It is a completely autonomous system with integrated electric and hydraulic power supply systems.

The Vigilant system is armed with twin Oerlikon-Contraves KBA cannon with the elevating mount being similar to that employed on the SIDAM 25 quad 25 mm self-propelled anti-aircraft gun system currently in service with the Italian Army. Full details of the SIDAM 25 are given in the *Self-Propelled Anti-aircraft Guns* section earlier in this Yearbook.



Model of Breda/Oerlikon-Contraves Vigilant twin 25 mm anti-aircraft gun in firing position

The 25 mm KBA cannon are mounted one above the other. The weapon is positively locked and gas-operated, with a rotating bolt head. One of the two cannon is fitted with a dual belt feed system to allow immediate selection from two ammunition types.

NATO standard 25 mm KBA ammunition is fired, which includes HE, SAP and APDS types with the latter having a muzzle velocity of 1335 m/s. The cyclic rate of fire is 600 rds/min from each barrel, or 1200 rds/min for the complete system.

Fire is directed by the Galileo P75 optronic fire control system which includes a laser rangefinder and a digital computer, or the weapon may be aimed using a ground-based radar system. Firing from a static position is accomplished after the outriggers are extended when the system rests on four points.

### SPECIFICATIONS

CALIBRE	25 mm
LENGTH OF BARREL	2000 mm
RECOIL FORCE (per gun)	2500 daN
FEEDING MECHANISM	fully automatic
RATE OF FIRE (cyclic)	600 rpm
MUZZLE VELOCITY	1100 to 1335 m/s
TIME OF FLIGHT (to 2000 m)	1.7 s (APDS)
TRAVERSE	360°
ELEVATION/DEPRESSION	-5°/+85°

**Status:** Under development as a private venture.

**Manufacturers:** Breda Meccanica Bresciana SpA, 2 Via Lunga, I-25128 Brescia, Italy.  
Telephone: (030) 31911  
Telex: 300056 BREDAR I

Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.

Telephone: (01) 306 22 11  
Telex: 823 402 coz ch  
Fax: (01) 301 34 66

Officine Galileo, Military Systems Division, Via A Einstein, I-35-50013 Campi Bisenzio (Florence), Italy.  
Telephone: (055) 89501  
Telex: 570126 GALILE I  
Fax: (055) 8950600

## NORWAY

### NFT 20 mm Automatic Anti-aircraft Gun FK 20-2

#### Development/Description

The 20 mm automatic anti-aircraft gun FK 20-2 is a joint development between Hispano-Suiza of Switzerland (now part of the Oerlikon-Contraves group), Norsk Forsvarsteknologi AS (previously A/S Kongsberg Vaapenfabrikk) of Norway, Rheinmetall GmbH of Germany and Kern and Company AG. The system, which was developed in the late 1960s, basically consists of a modified HSS 669 mount fitted with a Rheinmetall 20 mm automatic cannon (as installed in the Marder IFV, Luchs 8 × 8 reconnaissance vehicle, FIAT/OTO Melara Type 6616 armoured car and the twin 20 mm automatic anti-aircraft gun), with the cradle, ammunition cases and flexible feed channels designed by Kongsberg and the optical sight designed by Kern.

The FK 20-2 can be used against both ground and air targets and can be quickly dismantled without special tools into loads suitable for carrying over short distances. The FK 20-2 weighs only 620 kg in travelling order compared with the twin 20 mm MK 20 Rh 202 automatic anti-aircraft gun which weighs 2160 kg in travelling order.

The FK 20-2 consists of five main components, the cannon, cradle, upper mounting with seat, lower mount and carriage. The Rheinmetall 20 mm MK 20 Rh 202 cannon is gas-operated and fully automatic. Of 160

rounds of ammunition carried, 75 are in each of the side magazines and 10 rounds (normally APDS-T or API-T) in the magazine on top of the cannon. The following types of fixed ammunition (20 mm × 139) can be fired:

TYPE	APDS-T	API-T	HEI
GERMAN DESIGNATION	DM63	DM43A1	n/app
WEIGHT OF PROJECTILE	108 g	111 g	120 g
MUZZLE VELOCITY	1150 m/s	1100 m/s	1045 m/s
TYPE	HEI-T	TP/TP-T	Break Up
GERMAN DESIGNATION	DM51A2/ DM81	DM48/ DM48A1	DM78A1
WEIGHT OF PROJECTILE	120 g	120 g	120 g
MUZZLE VELOCITY	1045 m/s	1045 m/s	1045 m/s

More recently Raufoss has developed the new 20 mm NM75 multi-purpose round to meet the requirements of the German and Norwegian armies. This round does not detonate until it is inside of the vehicle and also has an improved incendiary effect.

The lower mount is of the tripod type and the two shorter trails may be disconnected for transport. The two-wheeled carriage is horseshoe shaped and the tow bar may be set at different positions to compensate for different towing vehicles.



20 mm automatic anti-aircraft gun FK 20-2 in travelling order

The cradle, which carries the gun and guides its recoil, is made of cast aluminium alloy and pivots on the upper mounting. It contains the recoil brakes, components forming part of the fire selector and trigger mechanism and a hinged frame assembly which contains the feeder mechanism and belt guides. The frame assembly can be latched semi-raised for quick inspection of the gun during action, and fully raised to remove the top feeder mechanism. The cocking crank is on top of the cradle.

The upper mounting holds the cradle and contains the elevation and traverse mechanisms which include adjustable twin gears to prevent play in the transmission. Operation of the quick-release locking device enables the upper mounting to be removed from the lower mounting. Fire selection, triggering and main locking controls are on the elevation and traverse handwheels. The optical sight is mounted between the handwheels. The gunner's seat can be folded forward to provide the gunner with a prone support position when the gun is being used against ground targets. The mount has a one-piece shield which can be removed.

The optical sight has a magnification of  $\times 5$  for use against ground targets and  $\times 1.5$  for use against air targets. The partially combined light paths for the air target sight give individual sighting images and optical values for both targets. Lead angle curves in the sight simplify firing against air targets at various speeds. The sighting image of the ground target sight comprises a simple cross-hair and range prediction lines for firing at targets at ranges of 500, 1000 and 1500 m.



20 mm automatic anti-aircraft gun FK 20-2 in firing position

#### Variants

The German Army fitted a number of its Kraka (4  $\times$  2) light cross-country vehicles with the 20 mm automatic anti-aircraft gun FK 20-2 for use in both the air defence and ground fire support roles.

#### 25 mm Mount

Details of this are given in the following entry.

#### SPECIFICATIONS

CALIBRE	20 mm
BARREL LENGTH (including muzzle brake)	2.61 m
OPERATION	gas, automatic
CARRIAGE	2-wheeled with outriggers
SHIELD	yes
WEIGHT	
travelling order	620 kg
firing position	440 kg
LENGTH	
travelling	4 m
firing	3.72 m
WIDTH	
travelling	1.86 m
firing	1.8 m
HEIGHT	
travelling	2.2 m
firing	1.2 m
AXIS OF BORE (firing)	0.58 m
GROUND CLEARANCE	0.38 m
TRACK	1.62 m
ELEVATION/DEPRESSION	+80°/-8°
TRAVERSE	360°
RATE OF FIRE (cyclic)	900 rpm
EFFECTIVE VERTICAL	
RANGE	1500-2000 m
CREW	3 (1 on gun)
TOWING VEHICLE	light (4 $\times$ 4) truck

**Status:** Production complete. In service with Germany (Army) and Norway (Army). Production can be resumed if further orders are received.

**Manufacturer:** Norsk Forsvarsteknologi AS, Manufacturing Division, PO Box 1003, N-3601 Kongsberg, Norway.  
Telephone: (473) 738250  
Telex: 11491  
Fax: (473) 738586

## NFT 25 mm Automatic Anti-aircraft Gun

#### Development/Description

The 25 mm automatic anti-aircraft gun system, also referred by NFT as the Mk 25 Model E Field Mount, is a further development of the older 20 mm system fully described in the previous mounting.

It can be used both in the ground and air defence roles and although primarily designed for towing, it may also be transported by helicopter or

transport aircraft. No special tools are required to dismantle the mount into loads suitable for manhandling over short distances.

The weapon is armed with a German 25 mm Mauser Mk 25 Model E automatic cannon with a cyclic rate of 1100 m/s with a total of 90 rounds of ready use ammunition being provided in two magazines each holding 45 rounds. The magazines are positioned one either side of the weapon and can be quickly replaced in the field.



The belts of ammunition are completely free in their boxes and are prevented from running back by a locking device in the feed mechanism. The spring loaded covers can be kept in a raised position to expedite attachments of boxes.

The optical sight has a magnification of  $\times 1.5$  for engaging air targets and  $\times 6$  for engaging ground targets. Lead angled curves in the sight simplify firing against air targets at various speeds. The sighting image of the ground target sight comprises simple crosshairs and range prediction lines for differing firing ranges.

The cradle, which carries the 25 mm cannon and guides its recoil, is made of cast aluminium alloy and pivots on the upper mounting. It contains

the recoil brakes, components forming part of the fire selection and trigger mechanism, and a hinged frame assembly which contains the feeder mechanism and the belt guides.

The frame assembly can be latched in a semi-raised position for a quick inspection of the gun during action and in a fully raised position to remove the feeder mechanism. The cocking crank is located on top of the cradle.

The upper mounting holds the cradle and contains the elevation and traverse mechanisms which include adjustable twin gears to prevent play in the transmission. Operation of a single quick release locking device enables the upper mounting to be removed from the lower mounting. The shield can be removed if required.

Firing selection, triggering and the main locking controls are located on the elevation and traverse handwheels. The gunners seat can be folded to provide the gunner with a prone support position when the weapon is being used to engage ground targets.

The two shorter trails may be disconnected for transport or storage purposes and the towbar can be set in several positions to compensate for differences in towing hook heights.

#### SPECIFICATIONS

CALIBRE	25 mm
LENGTH	4.6 m
WIDTH	1.86 m
WEIGHT	650 kg
ELEVATION/DEPRESSION	$+80^{\circ}/-8^{\circ}$
TRAVERSE	$360^{\circ}$
NUMBER OF READY ROUNDS	$90 \times 25$ mm
RATE OF FIRE	
Cyclic	900 rpm

**Status:** Development complete. Ready for production on receipt of orders.

**Manufacturer:** Norsk Forsvarsteknologi AS, Manufacturing Division, PO Box 1003, N-3601 Kongsberg, Norway.

Telephone: (473) 738250

Telex: 11491

Fax: (473) 738586



*NFT 25 mm Mk 25 Model E Field Mount light anti-aircraft gun deployed in the firing position*

## ROMANIA

### Twin 30 mm Anti-aircraft Gun

#### Development/Description

The Romanian army deploys at least one towed anti-aircraft system of local manufacture which is also believed to have been designed locally.

The system has been designed to engage aircraft flying at speeds of up to 300 m/s at altitudes from 50 m up to 3500 m with a maximum effective slant range of 4100 m. It can also be used to engage ground targets.



*Romanian twin 30 mm anti-aircraft gun system deployed in firing position with radar scanner on left side of mount*



*Romanian twin 30 mm anti-aircraft gun system deployed in the firing position from the rear*

The two 30 mm cannon have a cyclic rate of fire of 500 rounds per gun per minute and are provided with a flash suppressor on the muzzle and an ammunition supply magazine.

The system has three men on the mount with traverse 360° at 80°/s and elevation from -5 to +85° at a maximum speed of 50°/s.

The system weighs 3000 kg and is mounted on a four-wheeled carriage. When in the firing position it is supported on four points each being adjustable, one of these is at either end of the carriage and the other two on outriggers.

The system is normally towed by a Romanian DAC 665 T (6 × 6) truck which also carries the gun crew and ammunition.

The twin 30 mm anti-aircraft system can also be delivered fitted with the ACT-30 firing device on the left side of the mount. This includes a radar with a maximum range of 15 km. The system determines the motion parameters of the target, computes the firing data and automatically actuates the gun to move into correct elevation/traverse angle in order to engage the target. Firing data computation takes two seconds.

**Status:** Production as required. In service with Romanian Army.

**Manufacturer:** Romanian government facilities.

## SPAIN

### SA de Placencia de las Armas Bofors 40 mm L/70 Anti-aircraft Guns

#### Development/Description

The Sociedad Anonima de Placencia de las Armas has been licensed by AB Bofors for over 40 years for production of the 40 mm L/70 anti-aircraft gun. The company has produced approximately 400 40 mm L/70 guns for the Spanish Army and more for the Spanish Navy and for export. The company also produces the BOFI system for the 40 mm L/70 gun and carries out upgrading programmes for the Bofors 40 mm L/60 anti-aircraft gun.

Specifications for the 40 mm L/70 guns are identical to those of the Swedish model (see entry in this section).

**Status:** Production complete but can be resumed if further orders are placed. In service with the Spanish Army and Navy and other countries, including Saudi Arabia who took delivery of 72 systems.

**Manufacturer:** SA de Placencia de las Armas.

Head office: Apartado 8, E-20140 Andoain — (Guipuzca) — Spain.

Telephone: (43) 592011

Telex: 36176 SAPA

Fax: (43) 592703

Madrid office: Nunex de Balboa, 49 — 5°, E-28001 Madrid, Spain.

Telephone: (1) 4318080

Telex: 48340

Fax: (1) 4318196



*Key elements of Bofors 40 mm L/70 anti-aircraft gun upgraded by SA de Placencia de las Armas*

### Santa Barbara Meroka 20 mm Multi-barrel Anti-aircraft Gun System

#### Development

The Meroka 20 mm multi-barrel anti-aircraft gun system has been designed and developed by the Compañía de Estudios Técnicos de Materiales Espaciales (CETME) and is produced in land and sea versions. The naval version is in production and has been installed on Spanish Navy warships. The land version is still under development. The naval version uses a fully automatic fire control system developed by Lockheed Electronics but the towed land version uses a CETME optronic system.

CETME is now part of SANTA BARBARA SA and in 1988 was reported to be testing the Meroka 20 mm weapon system with a lightweight launcher for short-range air defence missiles mounted on top. The original Spanish Army requirement was for up to 100 trailer-mounted Meroka systems but as of late 1991 no firm in service date had been announced and no items ordered for production systems.

#### Description

The Meroka has 12 barrels to fire projectiles in salvos and each salvo has a virtual cyclic rate of fire of 24 rds/s or 9000 rpm; two salvos a second can be fired. The weapon operations (loading, feeding and unlocking) are carried out by compressed air from reservoirs mounted in the frame of the lower carriage that are recharged by a compressor during pauses in combat.

The 12 barrels are arranged in two superimposed rows and use a common breech-block. An adjustable clamp towards the ends of the barrels is used to optimise fire dispersion to suit the fire control system limitations. Feed is carried out using two munition belts, the ammunition is contained in a cylindrical drum containing 720 rounds, enough for 60 salvos. When loaded, fire can be opened almost immediately, the first salvo being fired within 0.08 seconds.

When ready for action the breech-block is at the rear and the ammunition is ready for feeding. The firer can then turn on the combat switch, the ammunition feed is made and the breech-block locks. When the trigger is

depressed the 12 rounds will be fired in four groups of three shots in about 0.08 seconds. When the fourth group has been fired a contact automatically activates the unlocking cycle and the breech-block moves to the rear, extracting the empty cases (along with any misfires). When the breech-block reaches its rear position, compressed air powers the transport cycle to draw the ammunition belts six steps to align 12 fresh rounds with the barrels. The feed cycle then starts to load the fresh rounds and lock the breech-block again for firing. These cycles are automatically repeated for as long as the trigger is kept depressed.

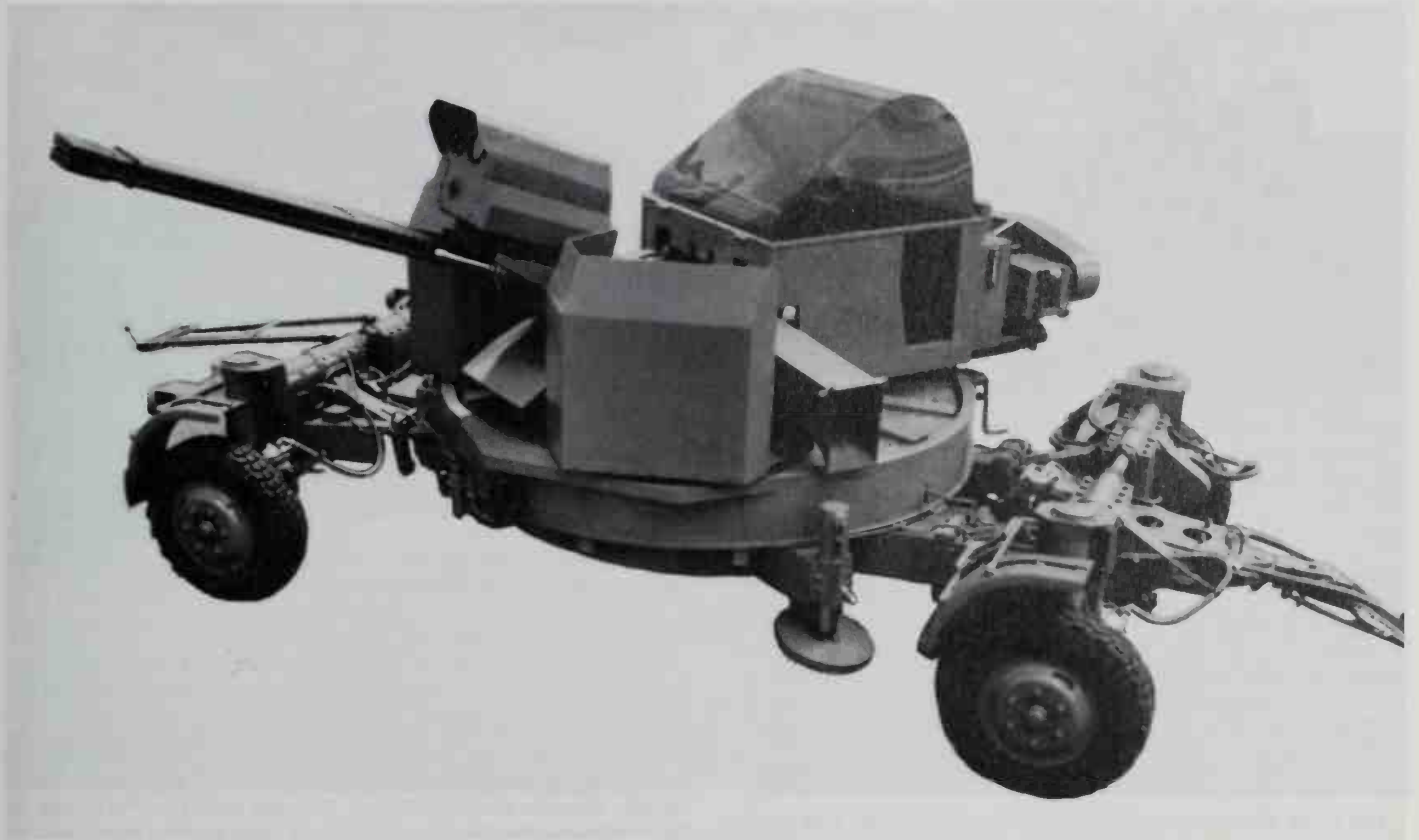
In action Meroka is controlled by one man who sits to the rear of the barrels under a clear housing. For fire control he has a laser rangefinder, a video tracking device, a prediction calculator, servo-electronic controls, control panel and a generator. The laser rangefinder has a wavelength of 1.06 µm and a repetition rate of 10 pulses per second; pulse energy is 65 mJ. The video system uses a camera with an automatic zoom feature with a focal length of between 30 and 300 mm. The camera is mounted over the barrels in a common housing with the laser rangefinder and the operator has a monitor in his control cab. The fire control system uses an analogue prediction calculator and power for the servo-electronic system is hydraulic. The operator has a control panel inside the cab which apart from the usual system controls has a built-in test system for first line maintenance. The generator is powered by a one-cylinder internal combustion engine which also powers the hydraulic system.

The ammunition fired is Oerlikon HE-I with a muzzle velocity of 1200 m/s. CETME has also developed a 20 mm APDS-T round with a projectile weight of 98 g and a penetrator weight of 72 g. Muzzle velocity is 1260 m/s with a velocity loss of 25 m/s every 100 m. The penetrator can pierce 40 mm of 100 kg/m<sup>2</sup> plate at 500 m and 30 mm at 1500 m. The projectile has an aluminium alloy shell body with a plastic protective ogive and the penetrator has a tracer element that lasts 2.5 seconds.

**Status:** Prototypes completed. Not yet in production or service.

**Manufacturer:** Compañía de Estudios Técnicos de Materiales Espaciales, (SA) (CETME), Julian Camarillo 32, Madrid-17, Spain.





*Meroka 20 mm multi-barrel anti-aircraft gun system in travelling configuration*

## SWEDEN

### Bofors 40 mm L/70 Automatic Anti-aircraft Gun

#### Development

The Bofors 40 mm L/70 automatic anti-aircraft gun entered service with the Swedish Army in 1951 as the successor to the 40 mm L/60 and is also manufactured under licence in India (qv), Italy (see separate entry in this section), Norway and Spain (production complete but can be resumed) and has been made under licence in Germany, the Netherlands and the United Kingdom.

#### Description

There were two basic models of the L/70, Types A and B. Type B has a 3-phase 220 V 50 Hz APU mounted on the rear of the carriage whereas Type A is fed from an external power source.



*Bofors 40 mm L/70 automatic anti-aircraft gun Type A fitted with muzzle velocity measuring equipment (German Army)*

The high rate of fire of 240 rds/min is obtained by ramming the rounds during the run-out, with the empty cartridge cases being ejected towards the end of recoil. The empty cartridge cases are deflected into a chute at the front of the mounting.

Ammunition is fed in four-round clips to the feed guides by the automatic loading device by two loaders positioned one either side of the gun. Waist-high supports protect the loaders against falling during the high training acceleration of the mounting. An ammunition stay can be placed on top of the automatic loading device to serve as a magazine, thus permitting 26 rounds to be fired from the unmanned gun. Two ready use ammunition racks, holding 48 rounds, are fitted at the rear end of the gun platform. These racks are fed from the outside by an ammunition supply party and are emptied from the inside by the two loaders.

The monobloc barrel is provided with a flash suppressor. The recuperator spring encircles the rear part of the barrel and this, together with the recuperator spring, forms an easily exchangeable unit. The recoil buffer is hydraulic and the breech mechanism has a vertically sliding breech-block which opens and closes automatically.

There are two close-range sights, model NIFE SRS 5, fitted on a sight bracket on the breech casing of the gun, one for the elevation layer and one for the traversing layer. Elevation and traverse are electrohydraulic with maximum elevation speed 45°/s and maximum traverse speed 85°/s. There are manual controls for emergency use.

In the remote-control mode the power operation devices for elevating and traversing are controlled by the input signals received from a fire control system connected to the gun by a cable. The Bofors precision remote-control system with transistorised amplifiers is used. In remote-control the data from the fire control equipment is transmitted with one cable and with Type B there is also a cable for connecting the gun with the power supply unit.

In local control the gun is operated by one man on the left side of the platform. This joystick is used in combination with the close-range sight if a central fire control equipment is not being used, is out of order, or if the gun is being operated as an independent unit.

A firing limiting gear for the electrical firing is provided and is set by pushing stop bolts, one for every 10° of traverse, and setting the highest limited elevation for any of the zones limited in traverse.

The following types of 40 mm ammunition are now produced by Bofors:



Bofors 40 mm L/70 automatic anti-aircraft gun system from rear with BOFI equipment, empty cartridge cases being ejected forward. This particular 40 mm L/70 has the ammunition stay fitted on top of the loading device (T J Gander)



Bofors 40 mm L/70 automatic anti-aircraft gun Type B in firing position

AMMUNITION TYPE	PFHE Mk 2	HCHE	HE-T	APC-T	P-T
WEIGHT OF COMPLETE ROUND	2.4 kg	2.4 kg	2.5 kg	2.5 kg	2.5 kg
WEIGHT OF SHELL	0.88 kg	0.87 kg	0.96 kg	0.92 kg	0.96 kg
WEIGHT OF EXPLOSIVE	0.12 kg	0.165 kg	0.103 kg	none	none
TYPE OF EXPLOSIVE	octal	octal	hexotonal	n/app	n/app
ROUND LENGTH	534 mm	534 mm	534 mm	534 mm	534 mm
MUZZLE VELOCITY	1025 m/s	1030 m/s	1005 m/s	1010 m/s	1005 m/s

The PFHE Mk 2 pre-fragmented round has a proximity fuze with an effective range of up to 6.5 m against aircraft and 4.5 m against missiles. Flight time to 1000 m is 1.1 seconds, to 2000 m 2.44 seconds and to 3000 m 4.44 seconds. The PFHE projectile is made up of high-grade steel which, together with the explosive charge, gives a large number of fragments. To increase the projectile's effectiveness 650 tungsten carbide pellets, with a penetration capability of about 14 mm of duraluminium, are contained in the walls of the forward section. Large fragment dispersion is improved by the 'boat tail' of the projectile.

The new High Capacity High Explosive (HCHE) shell is a multi-purpose projectile designed for use against all types of target from light aircraft to vessels and armoured personnel carriers. It can, to a certain extent, replace conventional types of HE and AP ammunition. The casing of the HCHE shell is manufactured from a special steel which is sufficiently strong to allow penetration of armour plate without breaking up. The shell also protects the post-impact delay fuze, which means it will explode only when inside the armoured target. The shell has a filling of 165 g of octal, a powerful high explosive.

More recently Bofors have developed two new rounds for 40 mm L/70 guns, these are the Pre-fragmented Programmable Proximity Fuzed 3P (PFPPX) and the Armour-Piercing Fin Stabilised Discarding Sabot (APFSDS).

The Bofors 40 mm L/70 anti-aircraft gun is normally used in conjunction with central fire control systems such as the Flycatcher designed by Hollandse Signaalapparaten and used by India and the Netherlands (Army and Air Force) and the Swiss Skyguard and Super-Fledermaus system. During 1980 the LM Ericsson Giraffe search radar, designed for use with the RBS 70 surface-to-air missile, was successfully used in conjunction with the 40 mm BOFI gun to shoot down an attacking missile.

Latest production versions of the Bofors 40 mm L/70 include the electrical power unit mounted on the gun, rate of fire increased to 300 rds/min (cyclic), hydraulic reversion to towing position, proximity fuze paralysing device and, as an option, a Doppler radar mounted on the right side of the weapon for measuring muzzle velocity.

### BOFI Fair-weather Gun System

The Bofors 40 mm BOFI (Bofors Optronics Fire control Instrument) gun system consists of a modified version of the basic 40 mm L/70 Type B, BOFI optronic fire control system and proximity fuzed ammunition. The FCE is integrated with the gun and is based on a computer which calculates the angles of aim-off to the target. The range to the target is continuously provided by a laser rangefinder. The movements of the target are measured by the operator continuously keeping the gun aimed at the target. Once tracking has been established the computer automatically takes over the aiming of the gun and all the operator has to do is to make minor corrections to obtain accurate tracking. The operator observes the target through a sighting device consisting of a combination day and night sight with a light amplifier.

Target designation is made by an optical target indicator or a central search radar linked to the BOFI gun via a target data receiver (TDR)

located beside the gun. Target data is transmitted to the TDR by wire or radio. By 1983 approximately 200 fair-weather BOFI guns had been delivered for service in Europe and Asia and Yugoslavia is known to have taken delivery of a quantity of these systems.

### BOFI All-weather Gun System

The all-weather BOFI gun system is in production with over 100 sold to date, Malaysia being the first customer. This version has a multi-sensor fire control using a J-band pulse Doppler radar as the main sensor. The radar gives the system an all-weather operation and automatic acquisition and tracking capabilities. It operates on the MTI mode at target acquisition and switches automatically over to frequency agility in the tracking mode, which radically improves tracking accuracy. The radar sensor can be backed up by the optronics for tracking supervision or noise tracking using radar for angular tracking and laser for ranging. All of the sensors can be used in different combinations for maximum flexibility and jam resistance. A total of 22 ready use and 96 reload rounds are carried on each BOFI mount with the gun normally firing two-second bursts of 10 rounds against a target using the PFHE Mk 2 ammunition which was introduced in 1982 to an effective range of over 4000 m.

### Netherlands 40 mm L/70 Upgrade

Late in 1987 Bofors was awarded a contract from the Royal Netherlands Army for the modernisation of 60 Bofors 40 mm L/70 anti-aircraft guns which were originally built in the Netherlands under licence in the 1950s. Bofors was awarded the contract, worth 220 MSEK, after the Royal Netherlands Army considered modernising the 40 mm L/70 weapons or purchasing new Oerlikon-Contraves twin 35 mm systems.

The contract covers the production of the modernisation kits and delivery of proximity fuzed ammunition. Dutch industry will be involved in the programme as the first six weapons were modernised by Bofors and delivered to the Netherlands in August 1989 with the remaining 54 weapons being modernised in the Netherlands by RDM Defence Engineering.

These modernised 40 mm L/70 guns will be used by three units of the Netherlands Army, one regular and two reserve with the first being operational in 1991. One Flycatcher fire control system will control two 40 mm L/70 anti-aircraft guns.

The modernisation includes the installation of a new servo system, new amplifiers, increased rate of fire kit (now to be 300 rds/min), ammunition racks and a diesel power unit.

### Spanish Bofors Upgrade

In 1987 the Spanish Army took delivery of its first Felis optronic automatic tracking system for the Bofors 40 mm L/70 anti-aircraft guns.

Felis consists of a high definition TV set with automatic tracking coupled to a telemetry laser, portable target designator and a radar interface. Spain uses the Contraves LPD-20 radar although other types can be utilised.

The system has three modes of operation: the first of these is radar acquisition which sends initial information to start the automatic tracking optical sequence; the second mode uses the portable autonomous visual designator which starts the same sequence while the third option uses a predetermined TV scanning pattern until acquisition is achieved.

Inisel is the prime contractor for the system previously called Linca and was developed by CETME.

By the end of 1987 one tracking system plus eight 40 mm L/70 weapons fitted with the kits were being used for trials purposes with a total of 100 systems due to be delivered to the Spanish Army from 1988 to 1993.

### Bofors Modernisation Package

The Bofors modernisation programme for the 40 mm L/70 covers the elevating mass, laying system, ammunition with the option of further modernisation alternatives and an external fire control system from SATT





*Bofors 40 mm L/70 automatic anti-aircraft gun with fair-weather BOFI equipment*

(Option A), or an integrated fire control system from Bofors Aerotonics (Option B). This uses the UTAAS which is also fitted to the upgraded Bofors 40 mm L/60 covered in the following entry. Additional details of the UTAAS system are given in the *Towed Anti-Aircraft Gun Sights* section.

In option A the analog data transmission via heavy cables is replaced by digital two-wire transmission, with the guns being equipped with a gun data receiver and external servo amplifier and the local control converter is replaced by a new servo amplifier built into the gun lower mounting.

In option B the Super-Fledermaus fire control system is discarded, the external amplifier and the local control converter are replaced by a gun amplifier integrated into the gun, which will also be integrated into an optronic fire control system.

The elevating mass modernisation system includes the installation of a 22- or 43-round magazine. As the 43-round magazine is divided into three sections, three types of ammunition can be loaded and ready to fire. The two outer sections contain 12 rounds each in clips of four rounds. The middle section contains 15 rounds without clips and in addition, the feeder holds four rounds.

The 22-round magazine can be combined with the existing ammunition rack for 48 rounds or with a new 96-round ammunition rack.

The 43-round magazine has to have the new 96-round ammunition rack to handle ammunition without clips.

The modernisation system also includes a kit that increases the cyclic rate of fire from 260 to 300 rds/min.

A kit has been developed that will enable existing 40 mm L/70 LAAGs, to fire the new programmable Bofors Pre-Fragmented Programmable Proximity Fuzed Ammunition (PFPPX) developed for the Trinity system, as well as the PFHE Mk 2, APFSDS-T, MP-T, HE-T and TP-T.

The PFPPX warhead contains more than 1100 tungsten pellets and its fuze can be programmed for multi-role capacity, enabling all types of target to be engaged by one type of round.

It has the same external dimensions as the standard 40 mm L/70 round and can be programmed for five different modes for the engagement of a variety of air and ground targets.

The PFHE Mk 2 round has a number of advantages, including automatic sensitivity control, and is equipped with separate advanced ECCM (Electronic Counter-CounterMeasure) circuits.

Also available is the MPT (multi-purpose tracer) round which is complementary to the PFHE Mk 2 as it can also be used against ground forces.

Under contract to FMV, Bofors has developed a new APFSDS-T round for the 40 mm L/70 gun installed in the new Combat Vehicle 90, a full tracked vehicle which is expected to enter service with the Swedish Army in the 1990s. This will be able to penetrate more than 100 mm of armour at a range of 2000 m.

Other options include the installation of a muzzle velocity measuring system, hydraulic switchgear, tilt angle correction system, new brake system,

integrated electric power supply unit, ammunition rack for 96 rounds and an enclosed operator's cabin.

### Electrical Power Supply Unit

This has been developed to meet the requirements of the Netherlands Army and is an on-mount self-contained, retrofittable, diesel powered electrical generator set. It provides the necessary power enabling the 40 mm L/70 to be fully autonomous and is fitted with an electric start motor and a fuel tank which has 20 litres of fuel, this being sufficient for eight hours of continuous use.

### SPECIFICATIONS (Types A and B)

CALIBRE	40 mm
BARREL LENGTH	2.8 m
RECOIL MECHANISM	hydro-spring
BREECH MECHANISM	vertically sliding
CARRIAGE	4-wheeled with outriggers
SHIELD	yes
WEIGHT IN TRAVELLING ORDER	
BOFI all-weather	5700 kg
BOFI fair-weather	5500 kg
Type A	4800 kg
Type B	5150 kg
LENGTH (travelling)	7.29 m
WIDTH (travelling)	2.225 m
HEIGHT (travelling)	2.349 m
AXIS OF BORE	
travelling	1.735 m
firing	1.335 m
GROUND CLEARANCE (travelling)	0.39 m
TRACK	1.8 m
WHEELBASE	4.025 m
ELEVATION/DEPRESSION	+90°/-4°
TRAVERSE	360°
RATE OF FIRE	260 rpm
FEED	4-round clip
NUMBER OF ROUNDS	
in ammunition stay	26
in racks	96
EFFECTIVE ANTI-AIRCRAFT RANGE	3000-4000 m
CREW	4-6
TOWING VEHICLE	3 t (4 × 4 or 6 × 6) truck

**Status:** Production as required and in service with the following countries:

Country	Quantity	User	Comment	Country	Quantity	User	Comment
				Italy	230	army	local production by Breda, used with Fledermaus FCS modified to CT/40-G, upgraded by Contraves with LPD-20 surveillance radar
Argentina	n/av	army	with Skyguard FCS				
Austria	60	army	with Super Fledermaus/Skyguard FCS				
Brazil	36+	army	Some are BOFI, also used with FILA FCS	Korea, South	n/av	army	
Chile	n/av	army	L/70 use unconfirmed	Libya	n/av	army	status uncertain
Colombia	n/av	army		Malaysia	30	army	some are BOFI
Denmark	n/av	air force	Super Fledermaus FCS upgraded from 1986	Malta	6	armed forces	
				Netherlands	60	army	with Flycatcher FCS
Ecuador	24	army			72	air force	with Flycatcher FCS
Finland	60+	army		Norway	64	air force	with Super Fledermaus FCS, upgraded by SATT from 1984
Germany	251	army	with Super Fledermaus FCS of which 50 came from Breda of Italy	Peru	40	army	
Greece	100	army	local production, Super Fledermaus is used but these will be supplemented by the Signaal Flycatcher system. The first order is for 40 systems (2 + 38) with an option being held on a further 212 systems which will include local production	Saudi Arabia	72	army	from Spain
India	800+	army	some may also be used by Marines	Singapore	16	air force	originally used Super Fledermaus for both 40 mm L/70 and twin 35 mm Oerlikon-Contraves cannon, but these are being upgraded with the Swedish SATT package
Indonesia	40	army	also used by Air Force	Spain	243	army	local production, getting Felis FCS
Iran	n/av	army		Sweden	600	army	
Ireland	2	army		Taiwan	n/av	army	L/70 use unconfirmed
Israel	n/av	air force	with Super Fledermaus FCS which is being upgraded locally	Thailand	48	army	from UK in 1987
				Turkey	n/av	army	also Air Force
				Venezuela	18	army	
				Yugoslavia	n/av	army	some are BOFI

**Manufacturer:** Swedish Ordnance (previously AB Bofors), S-691 80 Bofors, Sweden. It is, or has been, produced under licence in India (qv), Italy (see separate entry), Norway, Spain (by SA Placencia de las Armas, see separate entry), and UK (Royal Ordnance Nottingham). In 1988 Bofors stated that a total of 51 countries use 40 mm L/70 guns in army or naval configurations. Telephone: (0586) 81000 Telex: 73210 Fax: (0586) 58145

## Bofors 40 mm m/36 L/60 Automatic Anti-aircraft Gun

### Development

In 1928 AB Bofors started development of a 40 mm automatic anti-aircraft gun for both army and navy use. The first prototype of the army version was completed in 1931 and within a few years it had been adopted by almost 20 countries worldwide. Licensed manufacture of the 40 mm anti-aircraft gun was undertaken in a number of countries including Austria, Belgium, Brazil, Finland, France, Greece, Hungary, Italy, Norway, Poland and the United Kingdom.

There are at least three different Swedish carriages for the m/36: the m/38 (total weight of system 2150 kg), m/39 (total weight of system 2400 kg) and m/49e (total weight of system 2050 kg). The m/36 was succeeded in production after the end of the Second World War by the m/48 for which there is a separate entry. The list of user countries should be treated with caution as it is difficult to determine which particular model of the 40 mm Bofors gun (Swedish, British or US) some countries have in service.

### Description

In the firing position the weight of the carriage is supported on four screw jacks, one at either end of the carriage and one either side on outriggers. Ammunition is fed to the breech vertically in four-round clips with the empty cartridge cases being ejected under the forward part of the mount. The following types of fixed ammunition can be fired:

AP with the projectile weighing 0.89 kg and a muzzle velocity of 850 m/s, which will penetrate 52 mm of armour at an incidence of 0° at a range of 914 m; HE projectile weighing 0.955 kg with a muzzle velocity of 850 m/s.

In August 1984 Bofors Ordnance announced that LIAB (Lindesbergs Industri AB), a subsidiary, had collaborated with the company in the development of a 40 mm L/60 pre-fragmented proximity fuzed round, based on the same principles as used successfully in the L/70 Mk 2 round.

A special double-walled shell body containing hundreds of heavy metal pellets is charged with 100 g of the highly potent explosive octol to give a high penetration velocity to the pellets and shell fragments.

The effective initiation distance of the L/60 PFHE round is 6.5 m against aircraft and up to 4.5 m against missiles. The fuze incorporates a high-sensitive impact function, self-destruction and circuits to reduce initiation distance at very low altitudes. Muzzle velocity is 860 m/s.

LIAB has also developed a 40 mm L/60 APHC-T which has a 40 per cent increase in penetration compared to the original AP-T round. Ballistics of the APHC-T are the same as for the HET round.

### Variants

## Bofors 40 mm L/60 Upgrade Kit

Since the Bofors 40 mm L/60 was introduced in the 1930s the air defence threat has dramatically changed and the weapon must now be able to kill not only low flying aircraft and attack helicopters but also RPVs which have an increasing role on the battlefield. In addition it needs a self-defence capability against light armoured vehicles out to 1500 m.

The latest Bofors modernisation package includes the introduction of proximity fuzed ammunition, increasing its rate of fire from 120 to 200 rds/min, installation of a power laying system, adding a new 20-round magazine above the ordnance, installing an ammunition rack for 24 rounds and a loader's waist support, adding a slip-ring and fitting a new sight with laser rangefinder and fire control computer.

The modernised gun can also be fitted with an optical target indicator for target acquisition and be connected to a central search radar for target designation and combat control.

The user does not have to take the complete modernisation package at once but can take it step-by-step as funding becomes available or the threat evolves. The conversion work can be carried out by Bofors in Sweden or in the user's own facilities.

The rate of fire is increased by the installation of a new recoil buffer, recuperator spring and rammer pod.

The standard 40 mm L/60 has manual elevation and traverse but the modernised system has an electrohydraulic power laying system which not only shortens the reaction time but gives the gun a higher speed in traverse and elevation but also reduces the number of personnel as only one is now needed for aiming in both elevation and traverse.

Maximum traverse speed/laying speed is not less than 80°/s while maximum elevation speed is not less than 45°/s. Manual controls are retained for emergency use.

The installation of a 20-round magazine above the ordnance allows two bursts of 10 rounds to take place before reloading is required. The 24-round ammunition rack and loader's waist support make it possible, with





*Bofors 40 mm L/60 anti-aircraft gun fitted with full AB Bofors upgrading kit*

a loader standing on the gun, to reload the gun when it is firing. In turn this ammunition rack can be refilled continuously by an assistant loader.

A proximity fuze disconnecter is mounted on the elevating mass below the front guide extension and enables the operator to paralyse the proximity fuze in combat situations when an impact fuze function is preferred, for example when engaging ground targets.

The slip ring is installed to allow it to transmit signals between the upper and lower mounting which can be used for communication and designation of signals from an external fire control system or radar.

The installation of the UTAAS sight, which includes a laser rangefinder and computer, not only increases the hit probability of the weapon but also reduces training.

All the operator has to do is to aim at the target and when it is in range, depress the firing pedal. During firing the gun will continue moving the aim-off as calculated. Laser ranging is via the servo-controlled mirror with the sight having an 8° field-of-view and a magnification of  $\times 7$ . Full details of the sight are given in the following section.

The new operator's console is mounted on the gun platform and contains the sight control, gun control and joystick panels. A new adjustable operator's seat is also provided.

Bofors can supply a diesel engined power supply unit and an intercommunications system for communications between the operator and gun commander. Options include a TV camera for training, target designator equipment and target data receiver electronics and muzzle velocity radar.

With the aid of an external optical target indicator, target acquisition is simplified and reaction time shortened as the weapon is automatically trained onto the target area by pressing a button on the operator's panel.

By connecting the upgraded 40 mm L/60 weapon to a central search radar, targets can be engaged at a greater distance. The search radar can also be used to control a mix of 40 mm L/60 LAAGs and surface-to-air missiles such as the Bofors RBS 70.

Bofors have calculated a modernised 40 mm L/60 LAAG will have an effective range against a head-on target of approximately 2500 m and 3500 m against a side target.

Time taken to upgrade an existing 40 mm L/60 system to the new configuration depends on a number of factors, first delivery of upgrading kits would commence about 15 months after contract award.

### Weibull Kit

Details of the Swedish Weibull 40 mm L/60 modernisation package are given in the following entry.

#### SPECIFICATIONS

(m/39 carriage)

CALIBRE	40 mm
BARREL LENGTH	
56-calibre	2.24 m
60-calibre	2.4 m
OPERATION	recoil
RECOIL	hydro-spring
BREECH MECHANISM	vertical sliding block
CARRIAGE	4-wheeled with outriggers optional
SHIELD	
WEIGHT	
travelling order	2400 kg
firing position	2400 kg



*Basic unmodified Bofors 40 mm L/60 light anti-aircraft gun deployed in firing position*

LENGTH (travelling)	6.38 m
WIDTH	
travelling	1.72 m
firing	3.92 m
HEIGHT (travelling)	2 m
ELEVATION/DEPRESSION	+90°/-5°
TRAVERSE	360°
RATE OF FIRE (cyclic)	120 rpm (200 rpm when upgraded)
FEED	4-round clip
MAX RANGE	
horizontal	4750 m
vertical	4660 m
EFFECTIVE VERTICAL	
RANGE	2560 m
CREW	3-6
TOWING VEHICLE	2½ t (6 × 6) truck

**Status:** Production complete. In service with the following countries:

Country	Quantity	User	Comment
Argentina	n/av	army	may have been replaced by 40 mm L/70
Brazil	n/av	army	may have been replaced by 40 mm L/70
Denmark	36	army and air force	used with Super Fledermaus FCS
El Salvador	n/av	army	small number may be in service
Finland	n/av	army	some have been upgraded with Gather kit
Ireland	12	army	no fire control systems used
Nepal	2	army	no fire control systems used
Norway	32	air force	used with Super Fledermaus FCS, being upgraded, also used by Home Guard
Peru	n/av	army	
Portugal	40	army	
Senegal	80	army and air force	
South Africa	n/av	army	small number may be in service
Sudan	60	army	now in reserve
Sweden	n/av	army	status uncertain
Uruguay	2	army	
Venezuela	60	army	some may be Bofors 40 mm L/70
Zaire	n/av	army	status uncertain

**Manufacturer:** Swedish Ordnance (previously AB Bofors), S-691 80 Bofors, Sweden.

Telephone: (0586) 81000

Telex: 73210

Fax: (0586) 58145

## Weibull 40 mm Anti-aircraft Gun Update Package

### Development

J L Weibull started to develop sighting systems in 1970 by which time it already had some experience in power laying systems. In 1984 the company started to develop a gun update concept and the first prototype was complete in 1985 with first live firings in 1986.

The update can be done in steps with the first step, the Mk I consisting of a reflex sight with sight arm, the Mk II adds a power aiming system (all electric, aiming device, electric firing, power unit with backup and a new aimer's seat) while the Mk III adds a centre aimed sight system (sight arm, rotating table, sight, computer/calculating unit and a rangefinder). The latter can be a laser or a radar system.

Although the prototype systems are fitted to Bofors 40 mm L/60 weapons they are applicable to other air defence guns.

For the Bofors 40 mm L/60 weapon Weibull has collaborated with the LIAB ammunition company while for the Bofors 40 mm L/70 it has worked with the Swedish Defence Material Administration. According to Weibull this updating kit is applicable to many other types of anti-aircraft gun.

### Description

The power laying system comprises a control system using modern DC technology. DC motors connected to the gun via toothed belts, an aiming device with automatic lock-up when firing and electric firing replacing manual firing.

The fire control system comprises a sight arm attached to the gun using the existing screw holes, a rotating table which turns the optical sight laterally and vertically and carries the sensors which measure the movement in both axes, a I/J-band ranging radar positioned on the right side of the mount, or an Ericsson laser rangefinder, and a computing unit with advanced filter technology and the possibility of ammunition selection.

Both the power laying system and the fire control system are run from an on-mount 28 V DC power supply with battery backup.

As the gunner tracks the target, the onboard computer processes the sensor data to calculate the required lead angle and drive the rotating table



*Bofors 40 mm L/60 anti-aircraft gun fitted with update package from J L Weibull showing ranging radar on right of mount*

continuously to the correct aim-off point. The gunner then places his cross hairs back over the target and fires.

So far Weibull has built four prototype systems for extensive trials which have demonstrated that in the speed range of 100 m/s, 30 per cent of the rounds are within 4 m of target centre and at least 80 per cent are within 8 m. Using proximity fuzed pre-fragmented ammunition the target would be destroyed.

**Status:** Development complete. Ready for production. First production systems could be delivered within 12 months of receipt of order.

**Manufacturer:** J L Weibull AB, PO Box 43, S-232 02 Akarp, Sweden.

Telephone: (46) 40 465080

Telex: 33159

Fax: (46) 40 461677

## SWITZERLAND

## Oerlikon-Contraves Twin 35 mm GDF-002 and GDF-005 Automatic Anti-aircraft Guns

### Development

In the late 1950s the then Oerlikon-Bührle started the development of a twin 35 mm automatic anti-aircraft gun. The first prototype of this was completed in 1959 under the designation 1 ZLA/353 MK. This entered production as the 2 ZLA/353 MK but was subsequently redesignated the GDF-001. This model was also manufactured under licence in Japan for the Japanese Ground Self Defence Force.

In 1980 the GDF-002 model was introduced. This advanced version has a Ferranti instead of a Xaba sight and digital data transmission. By 1991 about 2000 GDF twin 35 mm systems had been produced with sales made to around 25 countries.



*Twin 35 mm Oerlikon-Contraves GDF-002 anti-aircraft gun of the Austrian Army, deployed in the firing position*

The Oerlikon twin 35 mm GDF-002 automatic anti-aircraft gun is used primarily as an anti-aircraft weapon but can also be applied against ground targets. It can be used on its own with its onboard optical sight but is normally used in conjunction with an off-carriage fire control system. A typical battery would consist of two GDF series anti-aircraft guns, each with a power supply unit and fire control unit. The fire control unit was originally the Contraves Super Fledermaus, now replaced in production in Switzerland by the Contraves Skyguard fire control system which is much more effective. The 35 mm cannon type KDB used in the GDF-002 are also used as a modified version (the KDC) in the GDM-A twin 35 mm naval gun system.

In May 1985 the GDF-005 was introduced. This is an overall improvement of the GDF-001/2/3 and the earlier models can be modified to the GDF-005 standard by the use of combat improvement kits supplied by Oerlikon. The GDF-005 features a new autonomous gun sighting system, an onboard power supply system, an automatic reloader and other improvements. The GDF-001 can be upgraded to any of the other gun standards by using kits. The GDF-B is particularly useful as it introduces an automatic ammunition replenishment from auxiliary magazines to the main magazines.

### Description

The Oerlikon-Contraves twin 35 mm GDF-002 automatic anti-aircraft gun consists of the following main components; two KDB (former designation 353 MK) cannon, cradle, two automatic ammunition feed mechanisms, upper mount, lower mount and the sighting system.

The Oerlikon KDB cannon is a positively locked gas-operated weapon. The weapon housing, together with the barrel, slides in the cradle during recoil. The cannon cover contains the ammunition feed mechanism and does not move during recoil. The manual cocking device is also mounted on the cannon cover. The barrels have progressive twist rifling, are fitted with muzzle brakes and if required can also be fitted with muzzle velocity measuring equipment.

The cradle is designed to carry both guns and is on the elevation axis. It contains the hydromechanical recoil mechanism which absorbs the recoil forces. The ammunition containers are on each side of the cradle and rotate with it. Each fully loaded ammunition container holds 56 rounds. The ammunition is reloaded in seven-round clips from the reloading container and passed through the upper mount trunnions to the cannon. The drive for the feed is independent of the cannons and uses electric spring motors. Rewinding the spring motors, which is normally automatic, can also be done manually.





Oerlikon-Contraves twin 35 mm GDF-005 automatic anti-aircraft gun in firing position with Contraves Skyguard fire control system in background

Traverse of the guns is determined by the upper mount which is in the pivot bearing of the lower mount. The upper mount platform supports the auxiliary aiming equipment, the seats for the crew and both 63-round reloading containers. The guns have a maximum elevation speed of 56°/s and a maximum traverse speed of 112°/s.

The lower mount forms the stable base of the gun. It comprises the two-axle chassis and the outriggers with the levelling spindles for three-point support in the firing positions. Raising and lowering the levelling spindles and raising the wheels are done electrohydraulically, or manually in case of power failure. The weapon can be brought into the firing position in 1.5 minutes by a crew of three or in 2.5 minutes by one. A hand pump is also fitted and when it is used the weapon can be brought into action in five minutes.

The sighting equipment consists of a GEC Ferranti sight Type GSA Mark 3, a ground target sight mounted on the Ferranti sight housing and an optical alignment sight. The target range is the only parameter to be adjusted in action on the Ferranti sight.

The following types of fixed ammunition can be fired:

OERLIKON DESIGNATION	MLD	MSD	SSD
NATO DESIGNATION	HEI-T	HEI	HEI
WEIGHT OF PROJECTILE	0.535 kg	0.55 kg	0.55 kg
EXPLOSIVE	0.098 kg	0.112 kg	0.07 kg
PROPELLANT	0.33 kg	0.33 kg	0.33 kg
COMPLETE ROUND	1.565 kg	1.58 kg	1.58 kg
MUZZLE VELOCITY	1175 m/s	1175 m/s	1175 m/s

OERLIKON DESIGNATION	PLD	ULD	UGD
NATO DESIGNATION	SAPHEI-T	TP-T	TP
WEIGHT OF PROJECTILE	0.55 kg	0.55 kg	0.55 kg
EXPLOSIVE	0.022 kg	n/app	n/app
PROPELLANT	0.33 kg	0.33 kg	0.33 kg
COMPLETE ROUND	1.552 kg	1.58 kg	1.58 kg
MUZZLE VELOCITY	1175 m/s	1175 m/s	1175 m/s

## Modification Packages

Oerlikon-Contraves is now offering a number of modification packages for the twin 35 mm GDF series of towed anti-aircraft guns and brief details of these follow:

COMBAT IMPROVEMENT KIT	NDF-A	NDF-C
FERRANTI SIGHT	yes	no
WEAPON OPTIMISATION	yes	yes
WEAPON LUBRICATION	yes	yes
CAMOUFLAGE	yes	yes
AUTOMATIC RELOADERS	no	yes
CAB FOR GUNNERS	no	no
INTEGRATED POWER SUPPLY	no	yes

The NDF-A kit comprises several changes, notably the addition of the Ferranti GSA Mk 3 sight for engaging air and ground targets, a quick-erect camouflage assembly, a transistorised power supply unit and the KDC-02 gun modification package. The NDF-C kit is used to bring any of the GDF-001/2/3 series up to the GDF-005 standard. In this version the gunner does not have a completely enclosed cab and the power unit is mounted on the rear of the trailer and lowered to the ground while firing so as not to impede the guns. A Gun King sight system is fitted.



Oerlikon-Contraves twin 35 mm GDF-001 automatic anti-aircraft gun of Japanese Ground Self Defence Force in travelling position (K Nogi)

By 1991 well over 200 NDF-C kits had been sold, with the customers including Austria, Finland, Switzerland (108 being upgraded to this standard) and Saudi Arabia.

## GDF-005

Introduced in May 1985 the 35 mm Oerlikon-Contraves GDF-005 has several overall improvements that can be retrofitted to existing GDF versions using modification kits.

One of the main improvements is the fitting of the Gun King 'three-dimensional' autonomous computer-controlled optronic sighting system which eliminates the need for the gunner to estimate target parameters. A built-in micro-computer processes all target data such as target range obtained via a laser rangefinder, muzzle velocity and meteorological data, to generate lead data for the gun control system. The Gun King system allows engagements out to a possible range of 4000 m. The addition of a fully automatic reloader reduces the number of crew on the gun from three to one (the layer) and at the same time the number of rounds on each gun has been increased to 280 rounds, enough for 10 combat bursts. The reloaders are powered by a hydraulic system which also supplies power for the automatic weapon and breech-block lubrication system (under a new gun cover) and power for the hydraulic emergency trigger systems. The cannon used are the type KDC with a breech recoil brake, rate of fire attenuation and a firing pin lock. A new onboard integrated power supply unit supplies not only the gun control systems



Replenishing the automatic loading unit of the Oerlikon-Contraves twin 35 mm GDF-005 air defence system with clips of ammunition



Model of Oerlikon-Contraves GDF-005 twin 35 mm anti-aircraft gun system showing some of the key parts of the system: computing 3D Gun King fire control unit; integrated power supply system and weapon cover with integrated cannon lubrication. Not visible are the new control and optimisation of the automatic cannon



Oerlikon-Contraves twin 35 mm anti-aircraft gun (centre) of No 2729 Squadron, Royal Auxiliary Air Force Regiment controlled by a Marconi Radar and Control Systems Apache mobile fire control unit (right) with operator in Land Rover (left)

but also provides power for emplacing the gun. When on site an electrohydraulic circuit is used to extend the outriggers, operate the jacks and pivot the carriage wheels to their inclined position. The power supply unit is also lowered to the ground. Levelling is carried out using a push-button control and for use in an emergency a hand-operated pump is provided. Permanently attached camouflage material is optional.

The weight of a fully loaded GDF-005 is 7700 kg, unloaded weight is 7250 kg.

Known customers of the GDF-005 include Canada, Cyprus and Malaysia.

## Anti-aircraft Gun 2000

Oerlikon-Contraves are convinced that the anti-aircraft gun has a future into the next century and are at present studying a number of systems of which one is called the Anti-aircraft Gun 2000. No firm details of this system have been announced so far.

## Skyguard Gun Missile System

Each battery will consist of one Contraves Skyguard fire control system, two missile launchers each with four Sparrow missiles in the ready to launch position and two twin Oerlikon-Contraves 35 mm GDF-002/003 or 005 cannon. Details of this system are given in the *Static and Towed Surface-to-Air Missile Systems* section.

### SPECIFICATIONS (GDF-001)

CALIBRE	35 mm
BARREL LENGTH	3.15 m
CARRIAGE	4-wheeled with outriggers
WEIGHT	
travelling order with ammunition and accessories	6700 kg
travelling order without ammunition and accessories	6300 kg
SWEPT RADIUS (at 0° elevation)	4.63 m
LENGTH	
travelling	7.8 m
firing	8.83 m
WIDTH	
travelling	2.26 m
firing	4.49 m
HEIGHT	
travelling	2.6 m
firing	1.72 m
AXIS OF BORE (firing)	1.28 m
GROUND CLEARANCE	0.33 m
TRACK	1.9 m
WHEELBASE	3.8 m
ELEVATION/DEPRESSION	+92°/-5°
TRAVERSE	360°
RATE OF FIRE PER BARREL (cyclic)	550 rpm
FEED	
ready use	112
reserve	126
total on gun	238
MAX EFFECTIVE RANGE (vertical)	4000 m
CREW	3 (local mode)
TOWING VEHICLE	5 t (6 × 6) truck

Status: GDF-001, 003 and 005 in production. In service with:

Country	Quantity	User	Comment
Argentina	100	army	GDF-002 with Skyguard fire control system
	n/av	air force	with Super Fledermaus FCS
	n/av	marines	small number delivered as GDF-002 (and called 3,5 cm Zwilling's FIAMK 75 bzw. 79) but now upgraded to GDF-005 standard, used with Skyguard FCS (called Feuerleitgerät 75 bzw. 79)
Austria	74	army	GDF-002, Super Fledermaus FCS
	18	air force	GDF-001, Super Fledermaus FCS
Brazil	38	army	GDF-001, Super Fledermaus FCS
Cameroon	6	army	Super Fledermaus FCS
Canada	20	army	GDF-005, Skyguard FCS, first deliveries 1988
Chile	24	army/air force	GDF-005, Skyguard FCS, first deliveries 1988
Cyprus	n/av	army	GDF-003 final deliveries in 1987, GDF-003 used with Skyguard FCS and Sparrow SAM, system is called Amoun
Ecuador	24	air force	GDF-002, upgraded to GDF-005 standard with kit
Egypt	36	air defence command	with Skyguard FCS delivered in 1980s with Skyguard FCS
			licensed production in 1970s, with Super Fledermaus FCS
Finland	n/av	army	GDF-003 delivered in 1988 and used with Skyguard also used for airfield defence
Greece	40	air force	with Skyguard FCS, upgraded with GDF-005 kit
Iran	100	army	GDF-002, used with Super Fledermaus
Japan	56	army	
Korea, South	18+	army	
Malaysia	9	army	
Pakistan	n/av	army	
Saudi Arabia	200	army/air force	
Singapore	34	air force	

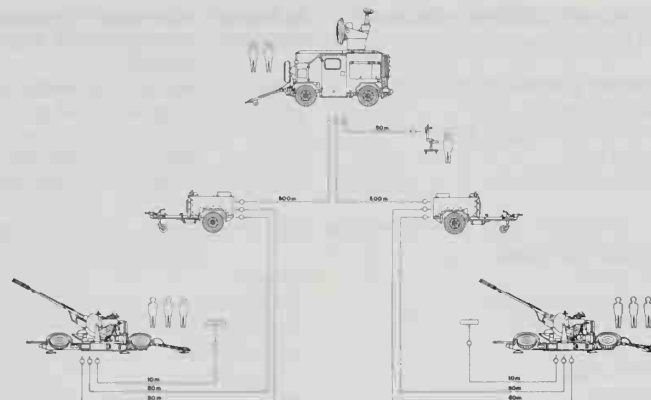




*Contraves Skyguard fire control system deployed in the field*

Country	Quantity	User	Comment
South Africa	150	army	FCS which are being upgraded with a SATT designed kit
Spain	96	army	GDF-002, with Super Fledermaus FCS, also uses LPD-20 surveillance radar
Switzerland	264	army/air force	with Super Fledermaus and Skyguard FCS
Taiwan	?	army?	with Skyguard FCS
Turkey	200	army	(108 being upgraded with NDF-C kit)
UAE	30	army	with Skyguard FCS
UK	12	air force	GDF-002 with Skyguard FCS, ex Argentinian

**Manufacturer:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.  
 Telephone: (01) 306 22 11  
 Telex: 823 402 coz ch  
 Fax: (01) 301 34 66



*Typical Oerlikon-Contraves twin 35 mm GDF-002 anti-aircraft gun battery comprising two guns, each with generator and Contraves Skyguard fire control system*



*Oerlikon-Contraves twin 35 mm GDF-005 deployed and showing generator mounted on rear of carriage*

## Oerlikon-Contraves 25 mm GBI-A01 Automatic Anti-aircraft Gun

### Development/Description

The Oerlikon-Contraves 25 mm GBI-A01 automatic anti-aircraft gun is fitted with a gas-operated Oerlikon-Contraves KBA-C cannon and can also be used to engage light AFVs and other battlefield targets. The weapon is normally manned by a crew of three, one on the mount and the other two acting as ammunition handlers.

The weapon has three firing positions:

- (1) normal firing position mounted on its tripod with an elevation of  $+70^\circ$ , depression of  $-10^\circ$  and a traverse of  $360^\circ$
- (2) mounted on its travelling carriage with the rear supported by the towing eye, with an elevation of  $+70^\circ$ , no depression and a traverse of  $360^\circ$
- (3) emergency mode with the carriage still coupled to the towing vehicle, with an elevation of  $+70^\circ$ , depression of  $-10^\circ$  and a traverse of  $45^\circ$  left and  $45^\circ$  right.

Elevation and traverse are manual with one revolution of the elevation handwheel giving  $4^\circ$  of elevation and one revolution of the traversing handwheel giving  $10^\circ$  of traverse. The gunner can declutch the traverse mechanism if required to give free traverse. The mount and travelling gear can be dismantled into individual loads.

The gunner can select either single-shot fire or full automatic and has a binocular sight for engaging ground targets and a delta sight for air targets. Mounted either side of the dual feed KBA-C cannon is a 40-round box magazine each of which weighs 33 kg when loaded. The following types of fixed ammunition can be fired:



*Oerlikon-Contraves 25 mm GBI-A01 automatic anti-aircraft gun in firing position*

OERLIKON DESIGNATION	TLB	SLB/SBB	PLB/PSB	ULB/UGB	WIDTH	
NATO DESIGNATION	APDS-T	HEI-T/HEI	SAPHEI-T/ SAPHEI	TP-T/TP	travelling	1.8 m
					liring	1.79 m
WEIGHT OF PROJECTILE	150 g	180 g	180 g	180 g	HEIGHT	
WEIGHT OF FILLING	105 g	91 g	91 g	91 g	travelling	1.65 m
WEIGHT OF COMPLETE					liring	1.45 m
ROUND	480 g	500 g	500 g	500 g	AXIS OF BORE	
MUZZLE VELOCITY	1335 m/s	1100 m/s	1100 m/s	1100 m/s	travelling	0.975 m
					firing	0.5 m
SPECIFICATIONS					GROUND CLEARANCE (travelling)	0.4 m
CALIBRE		25 mm			ELEVATION/DEPRESSION	+70°/-10°
BARREL LENGTH		2.182 m			TRAVERSE	360°
MUZZLE BRAKE		multi-baffle			RATE OF FIRE	
OPERATION		gas, automatic			cyclic	570 rpm
CARRIAGE		2-wheeled			practical	160 rpm
SHIELD		no			EFFECTIVE VERTICAL RANGE	2000-2500 m
WEIGHT					CREW	3 (1 on gun)
travelling order with ammunition		666 kg			TOWING VEHICLE	light (4 × 4) truck
travelling order without ammunition		600 kg				
firing position without ammunition		440 kg				
SWEPT RADIUS (at 0° elevation)		2.915 m				
LENGTH						
travelling		4.72 m				
firing		4.17 m				

**Status:** Production complete. This weapon is no longer offered.

**Manufacturer:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.  
Telephone: (01) 306 22 11  
Telex: 823 402 coz ch  
Fax: (01) 301 34 66

## Oerlikon-Contraves Twin 20 mm GAI-D01 Automatic Anti-aircraft Gun

(former designation HSS 666A)

### Development/Description

The Oerlikon twin 20 mm GAI-D01 automatic anti-aircraft gun was designed to fill the gap between single manual 20 mm anti-aircraft guns such as the GAI-C01, GAI-C03 and the GAI-C04 and the sophisticated and effective Oerlikon-Contraves twin 35 mm anti-aircraft gun Type GDF-002. It can be used as both an anti-aircraft and ground weapon and is normally operated by a detachment of five, with only one on the mount. The prototype was produced during 1976 and the first production example appeared in 1978.

The GAI-D01 is fitted with two 20 mm KAD cannon, left-feed model designated the KAD-B16 and a right-feed model designated the KAD-B17. The gunner can select either single shot, rapid single shot, automatic fire limited and automatic fire unlimited. Each cannon is provided with 120 rounds of ready use ammunition, with each full magazine weighing 68 kg. The following types of linked ammunition can be fired:

OERLIKON DESIGNATION	HLA	MLA	MSA	PLA	PSA	ULA	UGA
NATO DESIGNATION	AP-T	HEI-T	HEI	SAPHEI-T	SAPHEI	TP	TP-T
WEIGHT OF PROJECTILE	110 g	125 g	125 g	125 g	125 g	125 g	125 g
WEIGHT OF EXPLOSIVE	nil	5.6 g	10 g	4.7 g	4.7 g	nil	nil
WEIGHT OF PROPELLANT	53 g	53 g	53 g	53 g	53 g	53 g	53 g
WEIGHT OF COMPLETE							
ROUND	322 g	337 g	337 g	337 g	337 g	337 g	337 g
MUZZLE VELOCITY	1150 m/s	1100 m/s	1100 m/s	1100 m/s	1100 m/s	1100 m/s	1100 m/s

The upper mounting consists of the cradle with belt damper unit, counterweight for the elevating assemblies, Galileo P56 sighting and aiming unit, Wankel engine and an adjustable gunner's seat. Two compressed air containers on each side of the mounting provide compressed air for the electropneumatic operation of the trigger mechanism. The lower mounting consists of the tripod support and attachment points for the travelling carriage. The carriage is a tubular construction and has a towing-eye which is adjustable for height, independently sprung wheels and a hydraulically operated over-running brake which can also be operated by hand. The GAI-D01 can be brought into action from the travelling position with a team of five in 60 seconds.

Elevation and traverse are hydraulic, with maximum traverse speed of 80°/s and maximum elevation speed of 48°/s. Manual controls are provided for emergency use.

The Italian Galileo P56 sight is used to engage low-flying aircraft up to a range of 1500 m and surface targets to 2000 m. The target is initially engaged using the mechanical auxiliary sight and then located and tracked using the optical sight, which has a magnification of × 5 and a 12° field-of-view. In the 'air-target' mode (automatic/hydraulic) the unit calculates the overall lead on a continuous basis. Surface targets may also be engaged using this mode or a manual/mechanical mode.

The P56 sight consists of an optical sight, an electromechanically operated servo drive-unit for the view prism and a computer, plus a gun-laying



*Oerlikon-Contraves twin 20 mm GAI-D01 automatic anti-aircraft gun in firing position clearly showing Wankel engine under gunner's seat*

system consisting of a control-stick assembly, hydraulic unit, mechanical transfer gearboxes and manual controls.

Facilities are provided for integrating the GAI-D01 automatic anti-aircraft gun with an early warning radar such as the Contraves LPD-20, and connecting the gun to a remote input equipment specifying target speed, crossover point range, fire release and also incorporating a two-way intercom. An alternative sight with a radar data decoder was available.

### SPECIFICATIONS

CALIBRE	20 mm
BARREL LENGTH (overall)	1.906 m
OPERATION	gas, automatic
CARRIAGE	2-wheeled
SHIELD	yes
WEIGHT	
travelling order with ammunition	1800 kg
firing position with ammunition	1330 kg
SWEPT RADIUS (at 0° elevation)	3 m
LENGTH	
travelling	4.59 m
firing	4.555 m
WIDTH	
travelling	1.86 m



firing	1.81 m
HEIGHT	
travelling	2.34 m
firing 0° elevation	1.3 m
AXIS OF BORE (firing)	0.6 m
TRACK	1.86 m
ELEVATION/DEPRESSION	+81°/-3°
TRAVERSE	360°
RATE OF FIRE PER BARREL (cyclic)	1000 rpm
EFFECTIVE RANGE	1500-2000 m
CREW	5 (1 on gun)
TOWING VEHICLE	light (4 × 4) truck

**Status:** Production complete, no longer offered. In service with Guatemala, Turkey and other undisclosed countries.

**Manufacturer:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.  
Telephone: (01) 306 22 11  
Telex: 823 402 coz ch  
Fax: (01) 301 34 66

**Note:** Licensed production of this weapon is now being undertaken in Turkey (qv this section).

## Oerlikon-Contraves 20 mm GAI-C01 and GAI-C04 Automatic Anti-aircraft Guns

(former designations HS 693-B 3.1 and HSS 639-B5)

### Development/Description

Both are fitted with a gas-operated weapon, the GAI-C01 with an Oerlikon-Contraves cannon type KAD-B13-3 (former designation HS 820-SL7° A3-3) with single feed from the right, and the GAI-C04 with an Oerlikon cannon type KAD-B14 (former designation HS 820-SL7° A4) with dual feed. They can be used as both anti-aircraft and ground weapons and are normally manned by a crew of three, one on the mount and the other two acting as ammunition handlers. The mount is normally carried on a two-wheeled carriage that can be towed by most light vehicles and if required, the mount and carriage can be dismantled into individual loads.

Elevation and traverse are manual with one revolution of the handwheel giving 8° of elevation. Traverse is by using a pedal and the gunner can also declutch the traverse mechanism to give free traverse.

The gunner can select either single shots or full automatic and has a Delta IV reflector sight with a magnification of ×1 for engaging aerial targets plus a telescopic sight with a magnification of ×2.5 that can be swung into position for engaging ground targets. The aircraft sight has two graticules, one for aircraft flying at high speed (up to 900 km/h) and the other for slower flying aircraft or helicopters (up to 200 km/h). The graticules can be illuminated by two 4.5 V batteries.

Mounted on the right side of the GAI-C01 is a 75-round box magazine that weighs 44 kg when loaded, while the GAI-C04 has two 75-round box magazines, one each side of the mount. Ammunition details are as in the earlier entry for the Oerlikon 20 mm GAI-D01 anti-aircraft gun.

### Variant

The South African Army has a self-propelled version of this weapon on a 4 × 4 truck. Details are given in the *Self-Propelled Anti-Aircraft Guns* section under South Africa.

### SPECIFICATIONS

(data in square brackets relates to GAI-C04 where different from GAI-C01)

CALIBRE	20 mm
BARREL LENGTH	1.84 [1.906] m
OPERATION	gas, automatic
CARRIAGE	2-wheeled
SHIELD	no
WEIGHT	
travelling order with ammunition	534 [589] kg
travelling order without ammunition	512 [535] kg
firing position with ammunition	370 [435] kg
SWEPT RADIUS (at 0° elevation)	2.65 m
LENGTH (firing)	3.87 m
WIDTH (firing)	1.7 m
HEIGHT (firing)	1.45 m
AXIS OF BORE (firing)	0.5 m
ELEVATION/DEPRESSION	+83°/-7°
TRAVERSE	360°
RATE OF FIRE (cyclic)	1050 rpm
EFFECTIVE VERTICAL RANGE	1500-2000 m
CREW	3 (1 on gun)
TOWING VEHICLE	light (4 × 4) truck

**Status:** Production complete, no longer offered. In service with Chile (GAI-C01), Indonesia (10), Nicaragua, South Africa (GAI-C01) and other undisclosed countries.

**Manufacturer:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.  
Telephone: (01) 306 22 11  
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Fax: (01) 301 34 66



Oerlikon-Contraves 20 mm GAI-C01 automatic anti-aircraft gun in firing position



Oerlikon-Contraves 20 mm GAI-C04 automatic anti-aircraft gun in firing position

## Oerlikon-Contraves 20 mm GAI-B01 Automatic Anti-aircraft Gun

(former designation 10 ILa/5TG)

### Development/Description

The Oerlikon-Contraves 20 mm GAI-B01 automatic anti-aircraft gun is fitted with an Oerlikon-Contraves 20 mm cannon model KAB-001 (former designation 5TG) and is the lightest of the extensive Oerlikon range of anti-aircraft weapons. It can be used in both anti-aircraft and ground defence and is normally operated by a detachment of three with one on the mount and the other two acting as ammunition handlers. The mount is normally carried on a two-wheeled carriage that can be towed by most light vehicles but it can also be mounted on the rear of a 4 × 4 or a 6 × 6 truck chassis. If required the mount and carriage can be dismantled into individual loads.

The 20 mm GAI-B01 automatic anti-aircraft gun consists of four main components; the cannon, mount, aiming equipment and the carriage.

The Oerlikon-Contraves 20 mm automatic cannon KAB-001 is a positively locked gas-operated cannon with mechanical ignition and can fire single shots or automatic. The breech is cocked using the manual cocking device and is held open automatically after firing the last round. The lower part of the weapon recoils in the cradle together with the barrel, whereas the trigger housing is locked firmly with the cradle. Ammunition is fed from a magazine which can be changed in three seconds. Three types of magazine are available: 50-round drum weighing 41.5 kg loaded and 24.5 kg empty, 20-round drum weighing 23.5 kg loaded and 17 kg empty and 8-round box weighing 8 kg loaded and 4.5 kg empty.

Ammunition details are given in the entry for the Oerlikon 20 mm GAI-D01 anti-aircraft gun.

The mount is the standard base for the cannon and consists of the cradle with weight compensator and trunnions, pivot with elevation drive and trigger to support the cradle and allow elevation and traverse movement of the cannon, sight bracket to support the sight, tripod as a firm base when firing without the wheels in position and the chassis with slide plate for transport and rapid change of position. The gunner controls elevation with the upper handwheel, one revolution of which gives 10° of elevation. Traverse is free with the gunner's feet.

For engaging air targets an ellipse sight or a Delta IV sight can be fitted. The former can be used against aircraft and also ground targets after fitting a diopter. It has a glass fibre or metal graticule with the appropriate lead marks. The Delta IV sight can be used against aircraft and ground targets with the lead ellipse being controlled by a mechanical attachment. For engaging ground targets a telescope with a magnification of × 3.7 is secured to the cradle on a separate bracket. Effective range against a low flying aircraft is 1500 m whilst against helicopters it is 2000 m.

The two-wheeled carriage has a ground clearance of 0.34 m which can be reduced to 0.2 m by repositioning the wheels. A slide plate allows the gun to slide over obstacles.

When being used as an anti-aircraft gun the tripod legs are horizontal and the gunner is seated at the rear of the mount, the gun has an elevation of +85°, a depression of -5° and a total traverse of 360°.

When being used against ground targets the tripod legs remain horizontal but the gunner lies prone and uses the lower elevating gearing and the

lower trigger, the gun has an elevation of +25°, a depression of -5° and a total traverse of 60°.

The mount can also be set up in a higher position for engaging ground targets. The side spades are folded downwards and packing pieces are inserted. The towing hook which is used as a trail spade is pivoted downwards until the cannon is horizontal. When being used in this mode the gun has an elevation of +35°, a depression of -5° and a total traverse of 80°. In addition the gun can also be fired with the wheels in position.

The gun can be brought into action from the travelling position by two men in about 20 seconds. The chassis is pulled to the rear and the gun is placed on its tripod support.

### SPECIFICATIONS

CALIBRE	20 mm
BARREL LENGTH	2.4 m
OPERATION	gas, automatic
SHIELD	no
WEIGHT	
travelling order	547 kg
firing position	405 kg
SWEPT RADIUS (at 0° elevation)	2.99 m
LENGTH	
travelling	3.85 m
firing	4.71 m
WIDTH	
travelling	1.55 m
firing	1.55 m
HEIGHT	
travelling	2.5 m
firing	1.2 m
AXIS OF BORE (firing)	0.425 m
GROUND CLEARANCE	0.2 or 0.34 m
ELEVATION/DEPRESSION	+85°/-5°
TRAVERSE	360°
RATE OF FIRE (cyclic)	1000 rpm
EFFECTIVE VERTICAL RANGE	1500-2000 m
CREW	3 (1 on mount)
TOWING VEHICLE	light (4 × 4) truck

**Status:** Production complete. In service with many countries including Austria (1000), Singapore, South Africa, Spain and Switzerland (1700). Around forty 20 mm Oerlikons of unspecified type have been given to the Mojahedin guerrillas in Afghanistan. They are broken down into loads for carriage by animals or porters and have been used successfully against both Soviet fixed- and rotary-wing aircraft.

**Manufacturer:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.

Telephone: (01) 306 22 11

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Oerlikon-Contraves 20 mm GAI-B01 automatic anti-aircraft gun in firing position with 50-round drum magazine and optical sight



Oerlikon-Contraves 20 mm GAI-B01 light anti-aircraft gun mounted on rear of Steyr-Daimler-Puch 6 × 6 vehicle with carriage being towed behind truck to enable weapon to be deployed away from vehicle if required by tactical situation. Spare magazines are also carried on the vehicle



## Oerlikon-Contraves 20 mm GAI-C03 Automatic Anti-aircraft Gun

(former designation HS 639-B 4.1)

### Development/Description

The Oerlikon-Contraves 20 mm GAI-C03 automatic anti-aircraft gun is fitted with an Oerlikon-Contraves gas-operated 20 mm cannon model KAD-A01 (former designation HS 820 SAA1). The carriage and mount are identical to those used for the 20 mm GAI-C01 and GAI-C04 automatic anti-aircraft guns. The weapon can be used as both an anti-aircraft and ground gun and is normally crewed by a detachment of three, one on the mount and the other two acting as ammunition handlers. The mount is normally carried on a two-wheeled carriage which can be towed by most light vehicles and if required the mount and carriage can be dismantled into individual loads.

Elevation and traverse are manual with one revolution of the handwheel giving 8° of elevation. Traverse is controlled by a pedal and the gunner can also de-clutch the mechanism to give free traverse.

The gunner can select either single shots or full automatic and has a Delta IV reflector sight with a magnification of  $\times 1$  for engaging aerial

targets plus a telescopic sight with a magnification of  $\times 2.5$  that can be swung into position for engaging ground targets. The anti-aircraft sight has two graticules, one for aircraft flying at high speed (up to 900 km/h) and the other for slower flying aircraft and helicopters (up to 200 km/h). The graticules can be illuminated by two 4.5 V batteries.

Mounted over the cradle of the KAD-A01 cannon is a drum type magazine that holds 50 rounds of ammunition and weighs 36 kg loaded and 20 kg empty. Ammunition details were given in the earlier entry for the Oerlikon 20 mm GAI-D01 anti-aircraft gun.

### SPECIFICATIONS

CALIBRE	20 mm
BARREL LENGTH	2.24 m
OPERATION	gas, automatic
CARRIAGE	2-wheeled
SHIELD	no
WEIGHT	
travelling order with ammunition	510 kg
travelling order without ammunition	495 kg
firing position with ammunition	342 kg
SWEPT RADIUS	
(at 0° elevation)	2.65 m
LENGTH (firing)	4.27 m
WIDTH (firing)	1.7 m
AXIS OF BORE (firing)	0.5 m
ELEVATION/DEPRESSION	+83°/-7°
TRAVERSE	360°
RATE OF FIRE (cyclic)	1050 rpm
EFFECTIVE VERTICAL RANGE	1500-2000 m
CREW	3 (1 on gun)
TOWING VEHICLE	light (4 $\times$ 4) truck

**Status:** Production complete, no longer offered. In service with undisclosed countries.

**Manufacturer:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.  
Telephone: (01) 306 22 11  
Telex: 823 402 coz ch  
Fax: (01) 301 34 66



*Oerlikon-Contraves 20 mm GAI-C03 automatic anti-aircraft gun in firing position*

## Hispano-Suiza Anti-aircraft Guns

Hispano-Suiza was taken over by the Machine Tool Works Oerlikon-Bührle Limited (now Oerlikon-Contraves) in 1972. Some of its weapons were integrated into the Oerlikon-Contraves range and others phased out of production. Listed below is a résumé of the Hispano-Suiza anti-aircraft guns:

HS 630	This mount with three HSS-804 20 mm cannon is manufactured under licence in Yugoslavia as the 20 mm M55 and M75 anti-aircraft guns, details of which are given under Yugoslavia.
HS 639-B 3.1	Became Oerlikon GAI-C01 for which there is a separate entry
HS 639-B 4.1	Became Oerlikon GAI-C03 for which there is a separate entry
HS 639-B5	Became Oerlikon GAI-C04 for which there is a separate entry
HS 661	Armed with single HS 831 30 mm cannon. Some of these were still in service with the French Army in 1991
HS 665	Armed with three 20 mm cannon
HS 666	Became Oerlikon GAI-D01 for which there is a separate entry
HS 669	Armed with single 20 mm cannon
HS 673	Armed with single 20 mm cannon

### SPECIFICATIONS (HS 661)

CALIBRE	30 mm
SHIELD	yes
WEIGHT	
travelling order	1540 kg
firing position	1150 kg
SWEPT RADIUS (at 0° elevation)	3.595 m
LENGTH (travelling)	5.4 m
WIDTH (travelling)	1.86 m
HEIGHT (travelling)	2.4 m
AXIS OF BORE (firing)	0.575 m
ELEVATION/DEPRESSION	
manual	+83°/-5°
hydraulic	+81°/-3°
TRAVERSE	360°
CREW	3 (1 on gun)



*HS 661 30 mm anti-aircraft gun in firing position (ECP Armées)*

## THAILAND

### Royal Thai Air Force Anti-aircraft Guns

#### Development/Description

The Royal Thai Air Force (RTAF), Research and Development Office, has adapted some of their surplus M39 aircraft cannon for the anti-aircraft defence of airfields. Two different mountings are in use, one is a twin gun modification of the US supplied M55 quad 0.50/12.7 mm machine gun mount while the other is a hitherto unknown triple power mounting.

The 20 mm M39 cannon is a US design and is normally installed in the Northrop F-5A and F-5E/F fighter aircraft in service with the RTAF. Operating on the Mauser revolver principle, the M39 fires electrically primed 20 mm  $\times$  102 ammunition at a cyclic rate of fire of 1200 to 1500 rpm. At 162 kg ( $2 \times 81$  kg), two M39s represent only a slight increase in weight over the four 0.50/12.7 mm machine guns (162 kg) which they replace in the M55 modification. In contrast, the HS 404 20 mm cannon fitted in the Israeli TCM-20 system modification weigh only 45 kg each.

The great increase in rate of fire and recoil impulse means that the M39s mounted on the M55 mounts have to have muzzle brakes installed. The modified M55 mount retains the M18 reflex sight as in the case of the Israeli TCM-20 modification of the M55. The triple power mounting appears to be of a local design but mounted on surplus four-wheeled Bofors 40 mm carriages. When in the firing position the wheels are raised from the ground and the carriage is supported on four screw-type jacks, one at the front and rear and one either side on outriggers.

Being more robust than the M55, this mounting does not require the use of muzzle brakes as on the M39s. The sighting system appears to be an

AN/ASG-29 lead computing (disturbed line-of-sight) system removed from the F-5s.

At the combined rate of fire of some 3600 to 4200 rpm, this mounting provides impressive firepower with the added advantage of commonality, in both gun and ammunition, with the aircraft it is protecting. This system may have entered service in 1981.

The Royal Thai Air Force also has a requirement to upgrade their large stock of M55 mountings and in 1987 ISC Technologies presented a package called the Light Air Defense System (LADS) to meet this requirement. This involves upgrading the turrets electric and mechanical components, replacing the four 0.50/12.7 mm machine guns with two GIAT Industries M621 20 mm cannon and replacing the M18 reflex sight with a new dual-image lead estimating gunsight from Fraser Volpe. The GIAT Industries M621 cannon fires the same  $20 \times 102$  mm ammunition as the M39. It has roughly half the rate of fire of the M39, 750 vs 1500 rds/min, but is much lighter (58 kg vs 81 kg) and the lower recoil forces of the French gun probably give lower dispersion which compensates for its lower rate of fire.

The Royal Thai Air Force also operates Short Blowpipe SAMs, twin 30 mm Arrow air defence guns used in conjunction with Contraves Skyguard fire control systems and other towed anti-aircraft guns, (see *Inventory* section). More recently the Thai Air Force has taken delivery of Chinese twin 37 mm towed anti-aircraft guns.

**Status:** The triple 20 mm mount may be in front line service with the Royal Thai Air Force while the  $2 \times 20$  mm on M55 mount is believed to be still at the prototype stage.

## TURKEY

### Turkish Anti-aircraft Gun Production

The Machinery and Chemicals Industry Establishment at Cankiri is now producing the twin 20 mm GAI-D01 anti-aircraft gun system under licence from Oerlikon-Contraves of Switzerland. Full details of this weapon are given under Switzerland. By late 1988 a total of eight weapons had been completed with 80 per cent of the system being made in Turkey, the sight

and the engine being imported. It is believed that Turkey is also making the twin 35 mm Oerlikon-Contraves GDF series of towed anti-aircraft gun under licence.

Production of these weapons is undertaken at a facility at Cankiri. Once production is in full swing it is believed that about 50 GDF-003 and up to 100 GAI-D01 light anti-aircraft guns will be produced per year to meet the requirements of the Turkish Armed Forces.

## UNION OF SOVIET SOCIALIST REPUBLICS

### 130 mm Anti-aircraft Gun KS-30

#### Development

The 130 mm anti-aircraft gun KS-30 was introduced into service in the early 1950s and is the Soviet equivalent of the American 120 mm anti-aircraft gun M1 which is no longer in service. It is possible that the ordnance of the KS-30 was developed from a naval weapon of this calibre.

Development of the 130 mm KS-30 anti-aircraft gun commenced at Zavod No 9 at Kalinin in 1946 under M N Loginov and this has a 25 per cent increase in altitude over the 100 mm KS19 anti-aircraft gun. Development of the KS-30 was initially slow as it was decided to concentrate on surface-to-air missile systems for air defence. When it became apparent that it would take time to develop and deploy sufficient SAMs, development of the KS-30 and its associated fire control system was pushed ahead again.

The 130 mm KS-30 was deployed in 1955 and this, together with the 100 mm KS-19, was the backbone of Soviet anti-aircraft gun defences well into the 1960s although their effectiveness against high flying aircraft was limited. It was the largest calibre anti-aircraft gun used by the North Vietnamese and some have been deployed by Iraq in its conflict with Iran.

There were also plans for a 152 mm anti-aircraft gun with a maximum altitude of over 20 000 m, but this was never deployed. The KS-30 has now been replaced by surface-to-air missiles but KS-30s are still held in reserve.

#### Description

When travelling the KS-30 is carried on a two-axle, eight-wheel carriage and in the firing position the axles are removed and the four outriggers are swung from their folded vertical position into the horizontal position. To the rear of the mount is a firing platform which, when travelling, is folded up at an angle of 45°. The KS-30 is fitted with a power rammer and an automatic fuze setter.

The KS-30 is provided with on-carriage fire control equipment but is normally used in conjunction with the PUAZO-30 director and the SON-30 (NATO designation Fire Wheel) fire control radar.

The ammunition fired by the KS-30 is of the fixed charge, separate loading type which is not interchangeable with that fired by the 130 mm Field Gun M-46 or the 130 mm Coastal Gun SM-4-1. Ammunition is fed from the left and both the APHE and HE projectiles weigh 33.4 kg and have a muzzle velocity of 970 m/s. The APHE projectile will penetrate 250 mm of armour at an incidence of 0° at a range of 1000 m.

**Status:** Production complete. The only known front line users of the KS-30 today are Iraq (believed to have had approximately 200 weapons at start of the 1991 Gulf War but it is uncertain as to how many remain operational) and Vietnam. Unconfirmed reports are that Algeria has (10 to 20 weapons reported) 130 mm KS-30 anti-aircraft guns in service.

**Manufacturer:** Soviet state factories.



**SPECIFICATIONS**

CALIBRE	130 mm
BARREL LENGTH (overall)	8.412 m
MUZZLE BRAKE	none
BREECH MECHANISM	semi-automatic horizontal sliding wedge
CARRIAGE	2 axles, each with 4 wheels
SHIELD	none
WEIGHT	
travelling order	29 500 kg
firing position	24 900 kg
LENGTH (travelling)	11.521 m
WIDTH (travelling)	3.033 m
HEIGHT (travelling)	3.048 m
AXIS OF BORE	2.576 m
GROUND CLEARANCE	
(travelling)	0.408 m
TRACK	2.388 m
WHEELBASE	4.953 m
ELEVATION/DEPRESSION	+80°/-5°
TRAVERSE	360°
RATE OF FIRE	10-12 rpm
MAX RANGE	
horizontal	27 000 m
vertical	20 000 m
EFFECTIVE VERTICAL RANGE	13 720 m
CREW	15-20
TOWING VEHICLE	AT-T heavy tracked artillery tractor



130 mm anti-aircraft gun KS-30 in firing position with axles removed

## 100 mm Anti-aircraft Gun KS-19

### Development

The 100 mm anti-aircraft gun KS-19 was introduced in the late 1940s as the replacement for the 85 mm M1939 and M1944 anti-aircraft guns. It is no longer in service with the Soviet Union having been replaced by surface-to-air missiles, but it is still used by many other countries. The KS-19 has been manufactured in China as the Type 59.

### Description

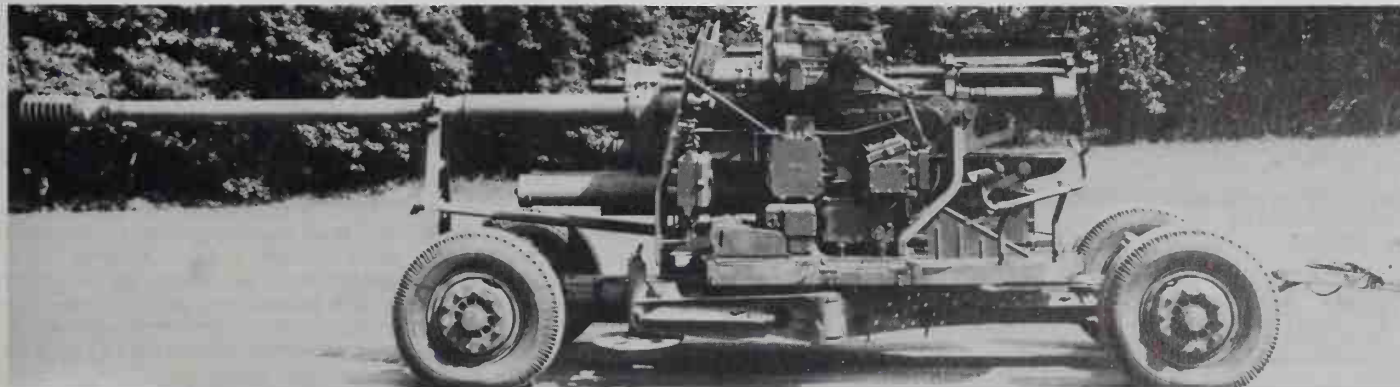
When travelling, the mount is traversed to the rear and the ordnance is held in position by a travelling lock at the rear of the carriage. In the firing position the wheels are raised off the ground and the carriage is supported on four screw jacks, one at each end of the carriage and one either side on outriggers. The KS-19 has a power rammer, automatic fuze setter and a single round loading tray. The KS-19 has on-carriage fire control equipment but is normally used in conjunction with the PUZO-6/19 director and the SON-9/SON-9A (NATO code name Fire Can and operated in the A/B-band) fire control radar. It is also reported that the KS-19 is used in conjunction with the PUZO-7 director and the SON-4 (NATO code name Whiff) fire control radar.

Ammunition is of the fixed type and is fed from the left. The following types can be fired:

Ammunition type	AP-T*	APC-T
PROJECTILE DESIGNATION	BR-412B	BR-412D
FUZE MODEL	MD-8	DBR-2
WEIGHT OF PROJECTILE	15.89 kg	16 kg
WEIGHT OF BURSTING CHARGE	0.56 kg	0.63 kg
TYPE OF BURSTING CHARGE	RDX/aluminium	RDX/aluminium
MUZZLE VELOCITY	1000 m/s	900 m/s

\*will penetrate 185 mm of armour at incidence of 0° at range of 1000 m

Ammunition type	HE	HE-FRAG	FRAG
PROJECTILE DESIGNATION	F-412	OF-412	O-415
FUZE MODEL	RGM	V-429	VM-30/VL-30L
WEIGHT OF PROJECTILE	15.91 kg	15.61 kg	15.44 kg
WEIGHT OF BURSTING CHARGE	2.159 kg	1.46 kg	1.58 kg
TYPE OF BURSTING CHARGE	TNT	TNT	n/app
MUZZLE VELOCITY	900 m/s	900 m/s	900 m/s



Late production model of KS-19, designated KS-19M2, in travelling order with outriggers retracted and ordnance in travelling lock

**SPECIFICATIONS**

CALIBRE	100 mm
BARREL LENGTH (overall)	5.742 m
MUZZLE BRAKE	multi-baffle
BREECH MECHANISM	semi-automatic horizontal sliding wedge
CARRIAGE	4-wheeled
SHIELD	yes
WEIGHT (travelling)	9550 kg
LENGTH (travelling)	9.45 m
WIDTH (travelling)	2.35 m
HEIGHT (travelling)	2.201 m
AXIS OF BORE	1.682 m
GROUND CLEARANCE	0.33 m
TRACK	2.165 m
WHEELBASE	4.65 m
ELEVATION/DEPRESSION	+85°/-3°
TRAVERSE	360°
RATE OF FIRE	15 rpm
MAX RANGE	
horizontal	21 000 m
vertical, proximity fuze	15 000 m
vertical, time fuze	12 700 m
EFFECTIVE VERTICAL	
RANGE (proximity fuze)	13 700 m
UNIT OF FIRE	100 rounds
CREW	15
TOWING VEHICLES	AT-S medium tracked artillery tractor
	AT-T heavy tracked artillery tractor

**Status:** Production complete. In service with the following countries:

Country	Quantity	User	Comment
Afghanistan	n/av	army	
Algeria	150	army	also used by Air Force
Bulgaria	n/av	army	
China	n/av	army/air force	built in China as Type 59



*Deployed 100 mm KS-19M anti-aircraft guns*

Country	Quantity	User	Comment
Cuba	75	army	
Egypt	300	air defence command	
Guinea	4	army	
Iraq	200	army	
Korea, North	500	army	
Morocco	10	army	believed no longer operational
Nicaragua	18	army	
Romania	30	army	
Somalia	24	army	
Sudan	n/av	army	
Syria	n/av	army	
Vietnam	n/av	air defence force	

**Manufacturer:** Soviet state factories.

## 85 mm Anti-aircraft Guns M1939 and M1944

### Development

The 85 mm anti-aircraft gun M1939 (KS-12) was designed by M N Loginov at Artillery Plant No 8, Kaliningrad near Moscow and was introduced into the Soviet Army shortly before the start of the Second World War as the replacement for the 76.2 mm M1938. The ordnance of the M1939 was later adopted for use in the SU-85 assault gun and later still the T-34/85 tank.

### Description

When travelling the mount is traversed to the rear and the ordnance is held in position by a travelling lock at the rear of the carriage. In the firing position the carriage is supported on four screw jacks, one at either end of the carriage and one either side on outriggers. The M1939 is often seen

without the shield. The original KS-12 had a built-up ordnance whereas the later KS-12A had a monobloc ordnance.

The M1939 is provided with on-carriage fire control equipment but is normally used in conjunction with the PUAZO-6/12 director and the SON-9/SON-9A (NATO designation Fire Can) A/B-band fire control radar.

The ammunition fired by the M1939 is of the fixed type, some of which is interchangeable with that fired by 85 mm assault guns, field and tank guns. In addition to firing all the rounds of the Soviet 85 mm field guns, the M1939 85 mm anti-aircraft gun has special cartridges with time-fuzed projectiles for firing at aircraft:

Ammunition type	FRAG	FRAG
PROJECTILE DESIGNATION	O-365*	O-365M
FUZE MODEL	T-5†	VM-2‡
WEIGHT OF PROJECTILE	9.2 kg	9.24 kg
WEIGHT OF BURSTING CHARGE	0.64 kg	0.776 kg
TYPE OF BURSTING CHARGE	TNT	TNT
MUZZLE VELOCITY	792 m/s	792 m/s

\* there are variants in O-365 projectiles giving different bursting charge weights as well as projectile weights

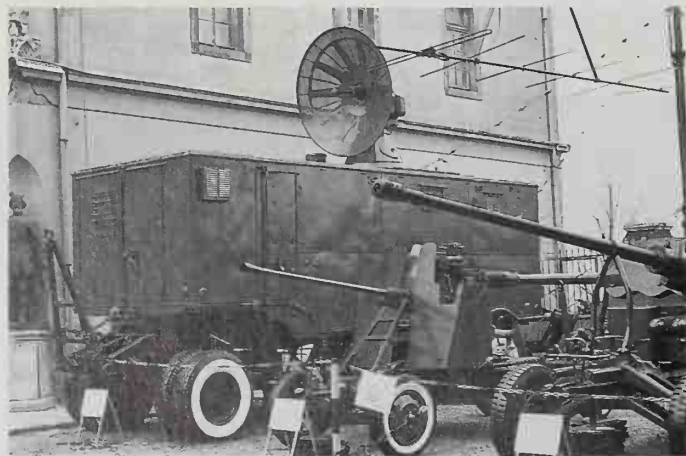
† powder train time fuze can be set from 1.6-32 s

‡ mechanical clockwork fuze can be set from 0.8-30 s

Other projectiles include: AP-T BR-365 (fitted with MD-5 fuze), AP-T BR-365K (fitted with MD-8 fuze), HVAP-T BR-365P (no fuze), HVAP BR-365-PK (no fuze).

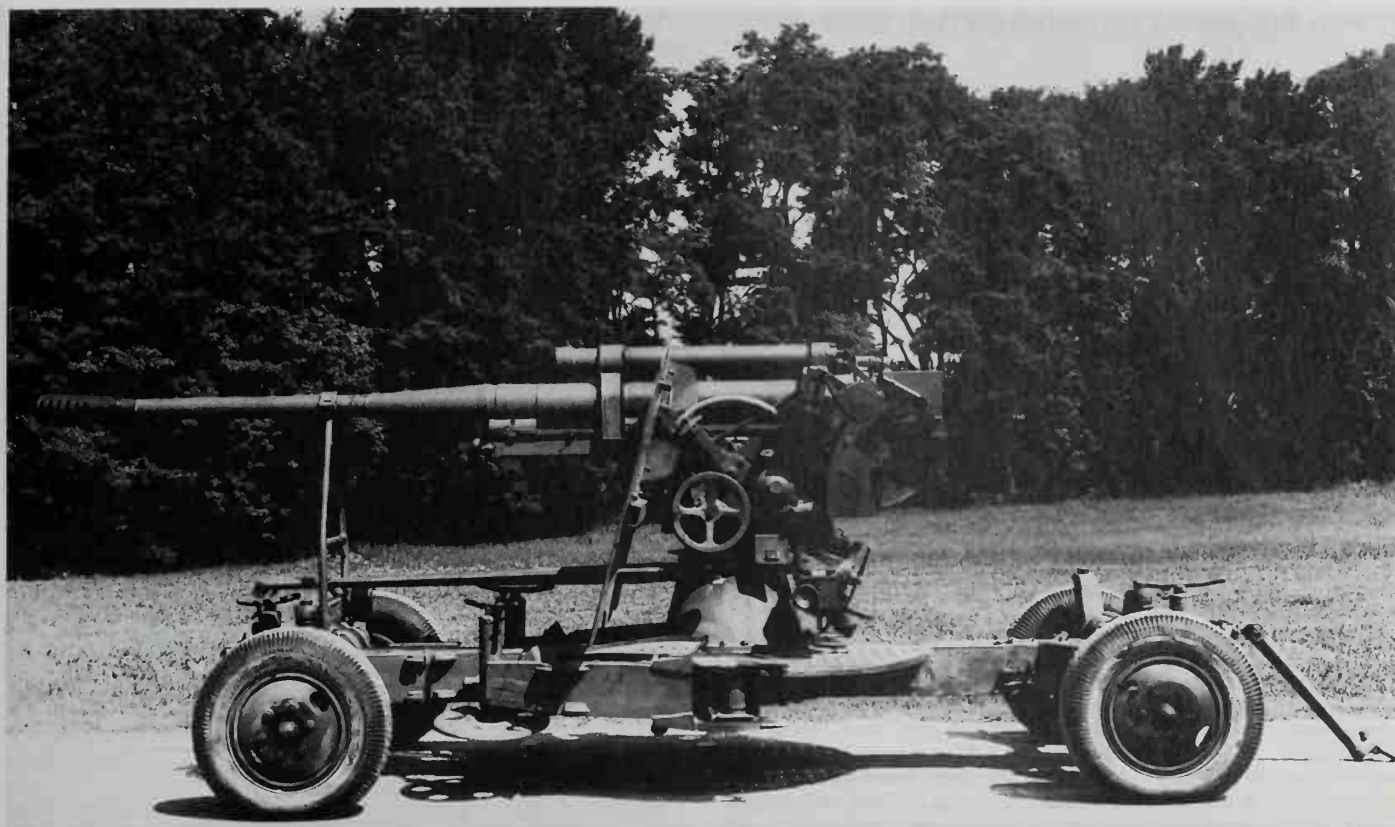
Effective slant range of the 85 mm M1939 is 8382 m, effective altitude limit with an elevation of +45° is 5944 m, effective altitude limit with an elevation of +65° is 7620 m while self-destruct range is 10 516 m.

The M1939 is known as the Type 56 in China. It was succeeded in production in 1944 by the M1944, which was designed by G D Dorokhin and had a number of modifications including a longer ordnance with a T-shaped muzzle brake and fired the same ammunition as the M1939 except that the HE round had a more powerful charge that increased its muzzle velocity to 900 m/s compared with the 792 m/s of the basic round. The complete HE round weighed 15.9 kg compared with the 15.1 kg of the standard round. The M1944 was not used by the Soviet Army in large numbers as it was soon replaced by the 100 mm KS-19. Production of the M1944 was undertaken in Czechoslovakia after the Second World War.



*Soviet SON-9 fire control radar which is used with a wide range of Soviet air defence guns including the 85 mm M1939 and M1944*





85 mm anti-aircraft gun M1939 in travelling order with outriggers retracted and ordnance in travelling lock

#### SPECIFICATIONS

(data in square brackets relates to M1944 where different from M1939)

CALIBRE	85 mm
BARREL LENGTH (overall)	4.693 [5.743] m
MUZZLE BRAKE	multi-baffle [T-shaped]
RECOIL	hydraulic buffer and hydro-pneumatic recuperator
BREECH MECHANISM	semi-automatic vertical sliding wedge
CARRIAGE	2-axle, 4-wheeled
SHIELD	yes
WEIGHT	
travelling order	4300 [5000] kg
firing position	4300 [5000] kg
LENGTH (travelling)	7.049 [8.2] m
WIDTH (travelling)	2.15 m
HEIGHT (travelling)	2.25 m
AXIS OF BORE	1.55 m
GROUND CLEARANCE	
(travelling)	0.4 m
TRACK	1.8 m
TYRES	34.00 x 7
ELEVATION/DEPRESSION	+82°/-3°
TRAVERSE	360°
RATE OF FIRE	15-20 rpm
MAX RANGE	
horizontal	15 650 [18 000] m
vertical	10 500 [11 600] m
EFFECTIVE VERTICAL	
RANGE	8382 [10 000] m
UNIT OF FIRE	150 rounds
CREW	7
TOWING VEHICLE	ZIL-157 (6 x 6) truck

**Status:** Production complete. In service with the following countries:

Country	Quantity	User	Comment
Afghanistan	n/av	army, air force	with Fire Can radar
Albania	n/av	army	with Fire Can radar
Algeria	20+	army	with Fire Can radar
	30+	air force	with Fire Can radar
Bulgaria	n/av	army	with Fire Can radar
China	n/av	army	with Chinese radar
	n/av	air defence force	with Chinese radar
Cuba	100	army	with Fire Can radar
Egypt	400	air defence command	with Fire Can radar
Iran	n/av	army	unconfirmed user
Iraq	200 (?)	army	with Fire Can radar
Korea, North	400	army	with Fire Can radar
Romania	75	army	with Fire Can radar
Sudan	n/av	army	with Fire Can radar
Syria	n/av	army	with Fire Can radar
Vietnam	n/av	air defence command	with Fire Can radar
Yemen	20	army	with Fire Can radar
Yugoslavia	260	army	with Fire Can radar
Zambia	16	army	with Fire Can radar

Note: Some Eastern European countries, including the Soviet Union, hold quantities of these weapons in reserve

**Manufacturers:** Czechoslovakian and Soviet state factories (Artillery Plant No 8, Kaliningrad, near Moscow and evacuation site in Sverdlovsk).



85 mm anti-aircraft guns M1944 deployed in the firing position and showing different muzzle brake to earlier M1939

## 57 mm Automatic Anti-aircraft Gun S-60

### Development

The 57 mm automatic anti-aircraft gun S-60 was designed by L V Loktev and introduced in 1950 as the replacement for the older 37 mm M1939 anti-aircraft gun. Main improvements over the latter include greater range and the facility to use an off-carriage fire control system.

In the Soviet Army the S-60 was issued on the scale of 24 per Tank Division and 24 per Motorised Rifle Division. Each of them had an anti-aircraft regiment which had four batteries each of six guns, with each battery having two three-gun platoons. The HQ battery had two Flat Face target acquisition radars and each four gun batteries had a single Fire Can fire control radar. The S-60 has now been replaced in front line units by the SA-8 'Gecko' mobile SAM system.

### Description

In the firing position its wheels are raised off the ground and the carriage is supported on four screw jacks, one at the front and one at the rear of the carriage, and one either side of the carriage on outriggers. The gun can be fired from its wheels in an emergency. Fire control equipment consists of a reflex sight for anti-aircraft use and a telescope sight for ground use. There are four modes of operation: manual, with the handwheels operated by the crew; assisted, with the handwheels operated by the crew assisted by a servo motor; automatic, remotely controlled by a director and zero indicator, remotely controlled by radar.

When originally introduced it was used in conjunction with the PUAZO-5 director and the SON-9 radar but today it is used in conjunction with the PUAZO-6/60 director and the SON-9 or SON-9A (NATO name Fire Can) A/B-band radar, but in recent years improved director and radar combinations have entered service. Photographs of Soviet-built Flap Wheel I-band anti-aircraft radars associated with the 57 mm S-60 anti-aircraft gun in Iraqi service show that the radar has been modernised. A low light television camera, similar to that seen on the Land Roll radar on SA-8 vehicles and some Low Blow radars associated with the SA-3 system, has been mounted

on top of the Flap Wheel antenna. Flap Wheels with long cables have also been observed, enabling them to be placed 200 m away from the firing position. These modifications will increase the effectiveness of the S-60, especially when confronted by chaff or jamming.

The top of each side of the shield folds forwards through 180°. The ammunition, which is fed to the gun in four-round clips, is not interchangeable with that used by the 57 mm ASU-57 self-propelled anti-tank gun or the 57 mm towed anti-tank guns due to a different configuration. A horizontal feed tray on the left side of the mounting holds one clip of four rounds and a second clip can be placed on an upright stand that rotates with the mounting.

The following types of fixed ammunition can be fired by the S-60:

Ammunition type	FRAG-T	FRAG-T	APCT-T
PROJECTILE			
DESIGNATION	OR-281	OR-281U	BR-281*
FUZE MODEL	MG-57	MG-57	MD-10
WEIGHT OF PROJECTILE	2.81 kg	2.85 kg	2.82 kg
WEIGHT OF BURSTING CHARGE	0.168 kg	0.154 kg	0.018 kg
TYPE OF BURSTING CHARGE	RDX/	RDX/	RDX/
MUZZLE VELOCITY	1000 m/s	1000 m/s	1000 m/s
ARMOUR PENETRATION AT 0° OBLIQUITY	n/app	n/app	96 mm/1000 m 106 mm/500 m

\*also very similar BR-281U

Effective slant range using onboard optical sights is 3993 m which increases to 6005 m with radar, effective altitude limit with an elevation of +45° is 2835 m with onboard optical sights and 3627 m with radar, effective altitude limit with an elevation of +65° is 4237 m with onboard optical sights and 5425 m with radar. Self-destruct range is 7224 m.

The S-60 is also manufactured in China as the Type 59. Details of the Type 59 and its associated fire control systems are given earlier in this section under China. The ZSU-57-2 twin 57 mm self-propelled anti-aircraft gun has the same ballistic performance as the S-60 and uses the same ammunition. Details of this clear weather anti-aircraft gun system are given in the *Self-Propelled Anti-Aircraft Guns* section. The Chinese equivalent of the ZSU-57-2 is the Type 80 SPAAG, details of which will be found in the relevant section. The 57 mm gun is also used in a number of naval applications.

### SPECIFICATIONS

CALIBRE	57 mm
BARREL LENGTH (overall)	4.39 m
MUZZLE BRAKE	multi-perforated
OPERATION	recoil, full automatic
CARRIAGE	4-wheel
SHIELD	yes
WEIGHT	
travelling order	4660 kg
firing position	4500 kg
LENGTH (travelling)	8.6 m
WIDTH (travelling)	2.054 m
HEIGHT (travelling)	2.46 m
AXIS OF BORE (firing)	1.3 m
GROUND CLEARANCE (travelling)	0.38 m



Close up of left side of 57 mm automatic anti-aircraft gun S-60 showing loading tray (Christopher F Foss)



57 mm automatic anti-aircraft gun S-60 in travelling configuration (Christopher F Foss)



TRACK	1.935 m
TYRES	34.00 x 7
ELEVATION/DEPRESSION	+87°/-2°
TRAVERSE	360°
RATE OF FIRE	
cyclic	105-120 rpm
practical	70 rpm
FEED	4-round clip
MAX RANGE	
horizontal	12 000 m
vertical	8800 m
EFFECTIVE VERTICAL RANGE	
with off-carriage fire control	6000 m
with on-carriage fire control	4000 m
UNIT OF FIRE	200 rounds
CREW	7
TOWING VEHICLES	ZIL-151 (6 x 6) truck Ural-375D (6 x 6) truck

**Status:** Production complete. In service with the following countries:



Country	Quantity	User	Comment
Afghanistan	n/av	army	also used by Air Force
Albania	n/av	army	
Algeria	75	army	
Angola	70	army	
Bulgaria	n/av	army	
Cambodia	n/av	army	
China	n/av	army	also used by Air Force, built as Type 59
Cuba	200	army	
Czechoslovakia	400	army	
Egypt	600	army	also used by Air Defence Command
Finland	12	army	
Guinea	12	army	
Guinea Bissau	10	army	
Hungary	144	army	
Indonesia	200	army	also used by Air Force, not all operational status and quantity uncertain
Iraq	500	army	
Iran	200	army	
Korea, North	600	army	
Laos	n/av	army	
Libya	90	army	
Mali	6	army	
Mongolia	n/av	army	
Morocco	60	army	
Mozambique	70	army	
Nicaragua	n/av	army	
Pakistan	n/av	army	from China
Poland	574	army	
Romania	150	army	
Somalia	20	army	
Syria	n/av	army	
USSR	n/av	army	
Vietnam	n/av	army	
Yemen	120+	army	
Yugoslavia	250	army	
Zambia	55	army	

**Manufacturer:** Soviet state factories. It has also been manufactured in Hungary under the designation of the SZ-60 and details of this are given under Hungary.

57 mm automatic anti-aircraft gun S-60 captured in Angola by South African Army in 1983 (South African Defence Forces)

## 37 mm Automatic Anti-aircraft Gun M1939

### Development

The 37 mm automatic anti-aircraft gun M1939 entered service with the Soviet Army shortly before the start of the Second World War and is based on the Swedish Bofors 40 mm design used by the UK and USA in the same period. The design was a joint task by L A Loktev and M N Loginov in the Design Bureau of Artillery Plant No 8 at Kaliningrad near Moscow.

The M1939 is built in China as the Type 55. A twin version built for export is known to be in service with Algeria and Egypt and is manufactured in China as the Type 65. The 37 mm gun has also been used by the Soviet Navy in both single (70-K) and twin liquid-cooled mounts (V-11M).

### Description

In the firing position its wheels are raised off the ground and it is supported by four screw jacks, one at the front and one at the rear of the carriage, and one either side on outriggers. When travelling the barrel is pointed to the rear and is held in position by a lock hinged at the rear of the carriage. The shield, which weighs about 100 kg, has been removed by many countries. The M1939 is a clear-weather system only with no provision for radar fire control.

The M1939 can fire the following types of fixed ammunition which is fed in clips of five rounds:



37 mm automatic anti-aircraft gun M1939 without shield deployed in firing position (Michael Green)



Twin version of 37 mm automatic anti-aircraft gun M1939 in service with Egyptian Army (Egyptian Army)

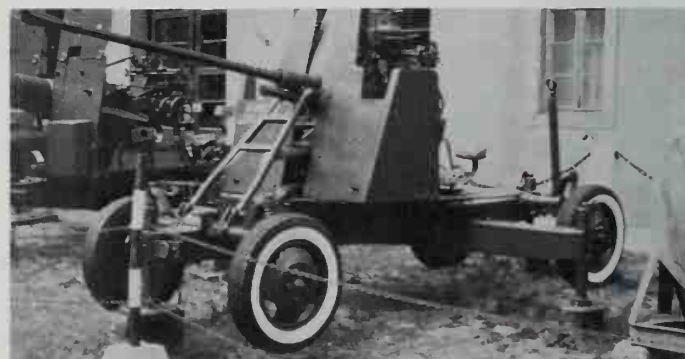
Ammunition type	FRAG-T	FRAG-T	AP-T *	Country	Quantity	User	Comment
PROJECTILE				Afghanistan	n/av	army	
DESIGNATION	OR-167	OR-167N	BR-167	Albania	50	army	
FUZE MODEL	MG-8	B-37	n/app	Algeria	150	army	
WEIGHT OF PROJECTILE	0.732 kg	0.708 kg	0.77 kg	Angola	n/av	army	
WEIGHT OF BURSTING CHARGE	0.035 kg	0.036 kg	n/app	Cameroon	18	army	from China
TYPE OF BURSTING CHARGE	RDX/	RDX/	n/app	Cambodia	n/av	army	
	aluminium	aluminium/		China	n/av	army	
		wax		Congo	28	army	
MUZZLE VELOCITY	880 m/s	880 m/s	880 m/s	Cuba	300	army	
ARMOUR PENETRATION AT 0° OBLIQUITY	n/app	n/app	37 mm/1000 m	Egypt	400	air defence command	
			47 mm/500 m	Ethiopia	n/av	army	
				Gabon	10	army	
				Guinea	8	army	
				Guinea-Bissau	6	army	
				Iran	300	army	
				Iraq	250	army	status and quantity uncertain
				Korea, North	1000	army	
				Laos	n/av	army	
				Mali	6	army	
				Mauritania	20	army	
				Mongolia	n/av	army	
				Morocco	25	army	
				Mozambique	n/av	army	
				Nicaragua	56	army	
				Pakistan	n/av	army	from China, Type 55 and Type 65
				Romania	100	army	
				Somalia	180	army	including some from China
				Sudan	120	army	including some from China
				Syria	n/av	army	
				Tanzania	120	army	from China, Type 55
				Thailand	50	army	from China in 1987, also used by Air Force for airfield defence
				Togo	6	army	

\* HVAP no longer used, it penetrated 57 mm of armour at 1000 m

The 37 mm M1939 anti-aircraft gun has an effective slant range of 2499 m. Effective altitude limit with an elevation of +45° is 1768 m and with an elevation of +65° is 2865 m. Self-destruct range is 4389 m.

#### SPECIFICATIONS

CALIBRE	37 mm
BARREL LENGTH (overall)	2.729 m
OPERATION	recoil
RECOIL	hydraulic recoil buffer and spring recuperator
BREECH MECHANISM	rising block
CARRIAGE	4-wheel
SHIELD	optional
WEIGHT (firing position without shield)	2100 kg
LENGTH (travelling)	6.036 m
WIDTH (travelling without shield)	1.937 m
HEIGHT (travelling without shield)	2.105 m
AXIS OF BORE (firing)	1.1 m
GROUND CLEARANCE (travelling)	0.36 m
TRACK	1.545 m
TYRES	6.50 × 20
ELEVATION/DEPRESSION	+85°/-5°
TRAVERSE	360°
RATE OF FIRE	
cyclic	160-180 rpm
practical	80 rpm
FEED	5-round clip
MAX RANGE	
horizontal	9500 m
vertical	6700 m
EFFECTIVE VERTICAL RANGE	3000 m
UNIT OF FIRE	200 rounds
CREW	8
TOWING VEHICLE	GAZ-63 (4 × 4) truck



37 mm automatic anti-aircraft gun M1939 fitted with shield and with outriggers in position (Franz Kosar)

Status: Production complete. In service with the following countries:



Country	Quantity	User	Comment
Tunisia	10	army	from China, Type 55
Uganda	20	army	
Vietnam	n/av	army	including some from China
Yemen	180	army	
Yugoslavia	400	army	not all operational
USSR	n/av	army	not in front line use, also used by Reserves and Militia
Zaire	n/av	army	
Zambia	40	army	
Zimbabwe	n/av	army	

There is a separate entry for the Chinese 37 mm weapons in this section.

**Manufacturers:** Soviet state factories, Artillery Plant No 8, Kaliningrad, No 4, Krasnoyarsk, No 586, Kolomna. Also Chinese and Polish state factories.

## Twin 23 mm Automatic Anti-aircraft Gun ZU-23

### Development

The twin 23 mm automatic anti-aircraft gun ZU-23 was introduced into the Soviet Army in the 1960s as the replacement for the 14.5 mm ZPU-2 and ZPU-4 anti-aircraft guns. In the Soviet Army it was issued on the scale of 24 per Airborne Division, 12 in the divisional artillery element and 4 in each of the 3 airborne rifle regiments. The Airborne Divisions have now been restructured as Airborne Rifle Divisions and recent TOEs show that they no longer have ZU-23 towed guns as part of their equipment. Instead they have 48 SA-9 'Gaskin' SAM systems, 12 in each of the three airborne rifle regiments and 12 in the divisional artillery element.

### Description

In the firing position the wheels are raised off the ground and the weapon is supported on its triangular platform which has three screw-type levelling jacks. The quick-change barrels have flash suppressors. The guns used in the ZU-23 are also used in the quad ZSU-23-4 self-propelled anti-aircraft gun system, but in this case the barrels are water-cooled.

The ZU-23 fires fixed ammunition with the same cartridge case dimension as the obsolete 23 mm automatic aircraft gun model VYa ammunition. The ZU-23 fires two types of ammunition, API-T (BZT) and HEI-T (MG25). The API-T projectile weighs 0.189 kg, has a muzzle velocity of 970 m/s and will penetrate 25 mm of armour at an incidence of 0° at a range of 500 m. The

HEI-T projectile weighs 0.19 kg and has a muzzle velocity of 970 m/s. The ZU-23 has an effective slant range of 2012 m with ammunition having a self-destruct range of 3780 m.

The ZU-23 is a clear-weather system only with no provision for radar fire control. Care must be taken not to confuse the 14.5 mm ZPU-2 (late model) with the ZU-23, which has different flash suppressors and horizontal rather than vertical ammunition boxes on either side.

There are separate entries for the Chinese and Egyptian built models of the ZU-23 light anti-aircraft gun systems.

### Variants

A single-barrel version also exists. During the fighting in the Lebanon in the summer of 1982 Israel captured a number of Soviet built BTR-152 (6 × 6) APCs with a ZU-23 anti-aircraft system mounted in the rear. It is believed that this was a local modification by the PLO. In Afghanistan the Soviets mounted the ZU-23 on the rear of ZIL-135 trucks for convoy escort.

### SPECIFICATIONS

CALIBRE	23 mm
BARREL LENGTH	
(overall)	2.01 m
OPERATION	gas, full automatic
BREECH MECHANISM	vertical sliding wedge
CARRIAGE	2-wheeled
SHIELD	no



Twin 23 mm automatic anti-aircraft gun ZU-23 of the Polish Army deployed in the firing position (Jane's Intelligence Review)

WEIGHT	
travelling order with ammunition	950 kg
firing position with ammunition	950 kg
LENGTH (travelling)	4.57 m
WIDTH (travelling)	1.83 m
HEIGHT (travelling)	1.87 m
AXIS OF BORE (firing)	0.62 m
GROUND CLEARANCE	0.36 m
TRACK	1.67 m
TYRES	6.00 x 16
ELEVATION/DEPRESSION	+90°/-10°
TRAVERSE	360°
RATE OF FIRE PER BARREL	
cyclic	800-1000 rpm
practical	200 rpm
FEED	50-round belt
MAX RANGE	
horizontal	7000 m
vertical	5100 m
EFFECTIVE VERTICAL RANGE	2012 m
UNIT OF FIRE	2400 rounds
CREW	5
TOWING VEHICLE	GAZ-69 (4 x 4) truck, MT-LB, BMD-2

**Status:** Production complete. In service with the following countries:

Country	Quantity	User	Comment
Afghanistan	n/av	army	also truck-mounted, used by militias and Ministry of Interior Armed Forces from China
Albania	n/av	army	
Algeria	50-60	army	
Angola	n/av	army	and Air Defence Force
Bulgaria	300	army	
Chad	n/av	army	
China	n/av	army	locally built, also Marines, Air Force and militia
Cuba	400	army	
Djibouti	24	army	
Egypt	n/av	army	locally built, also Air Defence Command
Ethiopia	n/av	army	
Finland	n/av	army	100 supplied by Germany in 1990/1991
Guinea-Bissau	18	army	
Hungary	n/av	army	and Air Defence Command
India	n/av	army	
Iran	300	army	and Air Force, Revolutionary Guard Corps
Iraq	750	army	and Air Defence Troops. Quantity and status of these weapons is uncertain including self-propelled
Israel	n/av	air force	
Korea, North	1500	army	
Laos	n/av	army	
Lebanon	n/av	army	and various militias

Country	Quantity	User	Comment
Libya	100	army	and Air Defence Force
Mauritania	n/av	army	
Mongolia	n/av	army	
Morocco	90	army	
Mozambique	120	army	
Nicaragua	30	army	
Oman	4	army	
Pakistan	n/av	army	from China
Peru	n/av	army	
Poland	242	army	also Air Defence Command and Troops of Territorial Defence
Somalia	50	army	
Sudan	n/av	army	from Egypt
Syria	n/av	army	also Air Defence Command
Tanzania	40	army	
USSR	n/av	army	also Air Defence Troops, KGB, MVD and militia
Uganda	20+	army	
Vietnam	900	army	
Yemen	30	army	
Zimbabwe	n/av	army	

Note: In Air Defence Command, they provide close in defence to SAM batteries and radar stations

To meet Egyptian requirements ESD and Thomson-CSF of France have each developed a self-propelled model of the ZU-23 based on an M113A2 chassis. Following extensive trials the ESD version was selected for service. The ZU-23 cannons are also used in the Israeli TCM Mk 3 light air defence artillery system described earlier in this section.

**Manufacturer:** Soviet state factories. Also license produced in China and Egypt; see entries in this section. It has also been built in Poland for both home and export markets.



BTR-152 (6 x 6) armoured personnel carrier with twin ZU-23 23 mm automatic anti-aircraft gun mounted in rear (Israeli Defence Forces)

## 14.5 mm ZPU Series of Anti-aircraft Machine Guns (ZPU-1, ZPU-2 and ZPU-4)

### ZPU-1

The ZPU-1 was introduced into the Soviet Army immediately after the Second World War and, like the ZPU-2 and ZPU-4, uses the 14.5 mm Vladimirov KPV heavy machine gun which has a quick-change barrel. It is also fitted to a number of AFVs including the T-10M tank, BRDM-2 reconnaissance vehicle, BTR-60PB (8 x 8) APC, BTR-70 (8 x 8) APC, BTR-80 (8 x 8) APC, Czechoslovak OT-64 (8 x 8) APCs models OT-64C(1) and OT-64C(2) and the OT-62C tracked APC.

The two-wheeled carriage of the ZPU-1 was designed by Vodop'yanov and Rachinskiy and for transport in rough terrain can be dismantled into units weighing about 80 kg each. The quick-change barrel is air-cooled, with the ammunition box on the right side. All weapons in this series fire the following fixed ammunition: API (BS 41) projectile weighing 64.4 g with a muzzle velocity of 1000 m/s which will penetrate 32 mm of armour at an incidence of 0° at a range of 500 m, API-T (BZT) projectile weighing 59.56 g

and I-T (ZP) projectile weighing 59.68 g. The 14.5 mm ZPU series of anti-aircraft machine guns have an effective slant range of 1402 m, effective limit at +45° elevation is 975 m while effective altitude limit at +65° is 1280 m.

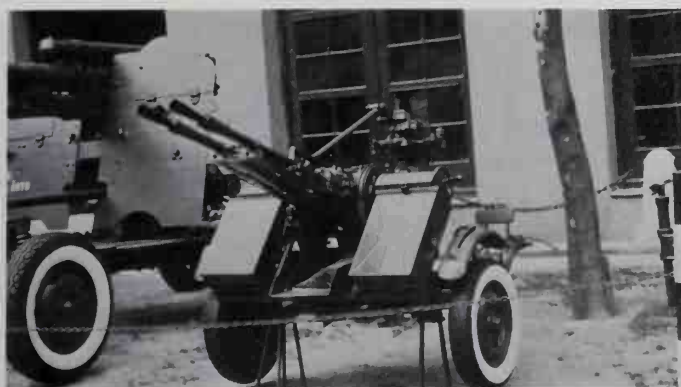
### ZPU-2

The first model of the ZPU-2 entered service in 1949 and had larger mudguards and a double tubular tow bar. In the firing position the wheels are removed and the weapon rests on a three-point platform, each point having a screw jack for levelling.

The late production model is lighter and lower and has narrower mudguards and a lighter single tow bar. In the firing position the wheels are raised clear of the ground but not removed.

The ZPU-2 is no longer in front-line service with Soviet units as it has been replaced by the similar 23 mm ZU-23 which is distinguishable by its ammunition boxes which are horizontal rather than vertical and its parallel flash hiders. The ZPU-2 is manufactured in China as the Type 58. Two self-propelled models in service are based on the BTR-40 (4 x 4) and the BTR-152 (6 x 6) APC and designated the BTR-40A and BTR-152A. Both





Late production model ZPU-2 (Franz Kosar)



Early model ZPU-2 in firing position

use the ZPTU-2 mount. Details are given in the *Self-Propelled Anti-Aircraft Guns* section.

## ZPU-4

The ZPU-4 entered service with the Soviet Army in 1949 and although no longer in front-line service with the Soviet Army, like the ZPU-2 may be found in second-line units defending airfields and other high-priority targets.

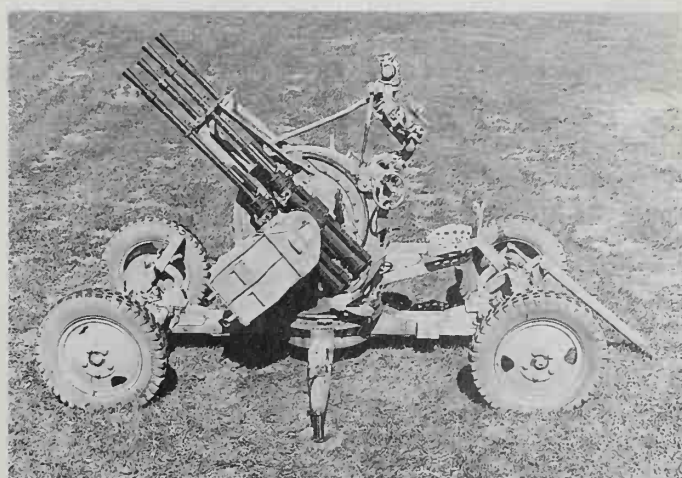
The ZPU-4 has a four-wheel carriage designed by Leshchinskiy. In the firing position the wheels are raised off the ground and the carriage is supported at four points, screw jacks at each end of the carriage and on outriggers on each side of the carriage that are also provided with screw jacks. The weapon can be brought into action in 15 to 20 seconds but can, if required, be fired with the wheels in the travelling position. The ZPU-4 is manufactured in China as the Type 56 and has been produced in North Korea, as is the ZPU-2.

### SPECIFICATIONS

Model	ZPU-1	ZPU-2 (early)	ZPU-2 (late)	ZPU-4
CALIBRE	14.5 mm	14.5 mm	14.5 mm	14.5 mm
BARREL LENGTH	1.348 m	1.348 m	1.348 m	1.348 m
CARRIAGE	2-wheeled	2-wheeled	2-wheeled	4-wheeled
WEIGHT				
travelling order	413 kg	994 kg	649 kg	1810 kg
firing position	413 kg	639 kg	621 kg	1810 kg
LENGTH (travelling)	3.44 m	3.536 m	3.871 m	4.53 m
WIDTH (travelling)	1.62 m	1.92 m	1.372 m	1.72 m
HEIGHT (travelling)	1.34 m	1.83 m	1.097 m	2.13 m
AXIS OF BORE (firing)	0.635 m	0.8 m	n/a	1.02 m
GROUND CLEARANCE (travelling)	0.28 m	n/a	0.27 m	0.458 m
TRACK	1.384 m	n/a	1.1 m	1.641 m
TYRES	4.50 × 16	6.50 × 20	6.50 × 20	6.50 × 20
ELEVATION/DEPRESSION	+88°/-8°	+90°/-7°	+85°/-15°	+90°/-10°
TRAVERSE	360°	360°	360°	360°
RATE OF FIRE PER BARREL				
cyclic	600	600	600	600
practical	150	150	150	150
MAX RANGE				
horizontal	8000 m	8000 m	8000 m	8000 m
vertical	5000 m	5000 m	5000 m	5000 m
EFFECTIVE VERTICAL RANGE	1400 m	1400 m	1400 m	1400 m
UNIT OF FIRE	1200 rounds	2400 rounds	2400 rounds	4800 rounds
CREW	4	5	5	5



Early model ZPU-2 in travelling order (US Marine Corps)



ZPU-4 anti-aircraft machine gun deployed in firing position and showing outriggers either side (US Army)



14.5 mm ZPU-1 anti-aircraft gun in firing position in Zimbabwe (UK Land Forces)

**Status:** Production complete. Known users include the following countries:

Country	Quantity	User	Comment
Afghanistan	n/av	army	ZPU-1, ZPU-2, ZPU-4, also used by militias and Ministry of Interior Armed Forces
Algeria	65	army	ZPU-2, ZPU-4
Angola	n/av	army	ZPU-1, ZPU-2, ZPU-4
Benin	n/av	army	ZPU-4
Bulgaria	n/av	army	ZPU-2, ZPU-4, not front line
Burkina-Faso	30	army	ZPU-4
Burundi	15	army	ZPU-4
Cameroon	15	army	Chinese Type 58 (ZPU-2 copy)
Cape Verde Islands	n/av	army	ZPU-2, ZPU-4
Chad	n/av	army	ZPU-1, ZPU-2, ZPU-4
China	n/av	army, militia and marines	locally built ZPU-1, ZPU-2 and ZPU-4
Congo	n/av	army	ZPU-4
Cuba	n/av	army	ZPU-1, ZPU-2 and ZPU-4
Czechoslovakia	n/av	army, militia	ZPU-4 not front line use
Egypt	n/av	army	ZPU-2, ZPU-4
Ethiopia	n/av	army	ZPU-1, ZPU-2, ZPU-4
Guinea	n/av	army	ZPU-4
Guinea-Bissau	n/av	army	ZPU-4
Hungary	n/av	army, militia	ZPU-2, ZPU-4, not front line
Iraq	n/av	army	ZPU-1, ZPU-2, ZPU-4
Korea, North	n/av	army	ZPU-1, ZPU-2, ZPU-4 (locally built)
Laos	n/av	army	ZPU-1, ZPU-2, ZPU-4



ZPU-4 in travelling order

Country	Quantity	User	Comment
Libya	n/av	army	ZPU-2, ZPU-4
Madagascar	50	army	ZPU-4
Malawi	n/av	army	ZPU-4
Mali	n/av	army	ZPU-4 from North Korea
Malta	50	task force	ZPU-4 from North Korea
Mauritania	n/av	army	ZPU-1, ZPU-2, ZPU-4
Mongolia	n/av	army	ZPU-2, ZPU-4
Morocco	200	army	ZPU-2, ZPU-4
Mozambique	n/av	army	ZPU-1, ZPU-2, ZPU-4
Nicaragua	100	army	ZPU-1, ZPU-2, ZPU-4
Pakistan	n/av	army	ZPU-2, ZPU-4 from China
Panama	n/av	army	ZPU-4
Poland	n/av	army, Troops of Territorial Defence	ZPU-2, ZPU-4, not in front line
Romania	n/av	army, MoD Security Troops, Patriotic Guard, Border Guards	ZPU-2, ZPU-4
São Tomé & Príncipe	n/av	army	ZPU-4
Seychelles	n/av	army	ZPU-4
Somalia	n/av	army	ZPU-1, ZPU-2, ZPU-4
Sudan	n/av	army	ZPU-2, ZPU-4
Syria	n/av	army, militia	ZPU-2, ZPU-4, not front line
Tanzania	240	army	ZPU-1, ZPU-2, ZPU-4, some reports state 160
Togo	38	army	ZPU-4 from North Korea
Uganda	n/av	army	ZPU-1, ZPU-2, ZPU-4
USSR	n/av	army, KGB, MVD, militia and Naval Infantry (reserve)	ZPU-1, ZPU-2, ZPU-4, not front line
Vietnam	n/av	army	ZPU-1, ZPU-2, ZPU-4
Zambia	n/av	army	ZPU-4
Zaire	n/av	army	ZPU-4
Zimbabwe	n/av	army	ZPU-1, ZPU-2, ZPU-4

**Manufacturers:** Chinese, North Korean and Soviet state factories. Details of the Chinese built versions of the ZPU series are given in this section under China.

## 12.7 mm NSV Heavy Anti-aircraft Machine Gun

### Development/Description

The 12.7 mm NSV heavy machine gun was designed in the late 1960s by a three-man team consisting of G I Nikitin, J M Sokolov and V I Volkov as the replacement for the older 12.7 mm DShK and DShKM weapons.

The first application was for the NSV vehicle turret-mounted version which is standard fit for the T-64, T-72 and the more recent T-80 MBTs.

The second version to enter service was the 6T7 tripod system which has manual traverse of 360° and manual elevation. Targets are engaged using a SPP K10-T collimating optical sight with iron sights being provided for backup.

The third model to enter service is a specialised air defence version called the 6U6 which consists of a tripod, weapon mount for the NSV heavy machine gun, folding seat for the gunner, VK-4 reflex anti-aircraft sight and a PU telescopic sight for engaging ground targets.

When engaging air targets the gunner operates from the sitting position with the seat folded up. The portable mount weighs 55 kg and 92.5 kg with the NSV machine gun and a box of 70 rounds of ammunition.

The weapon has a cyclic rate of fire of 680/800 rds/min with the barrel capable of being quickly changed after about 1000 rounds have been fired. It normally fires API ammunition with every fourth round being an API-T. The API will penetrate 20 mm of armour at a range of 500 m and 13.2 mm of armour at a range of 500 m. In addition to API and API-T rounds ball types can also be fired.

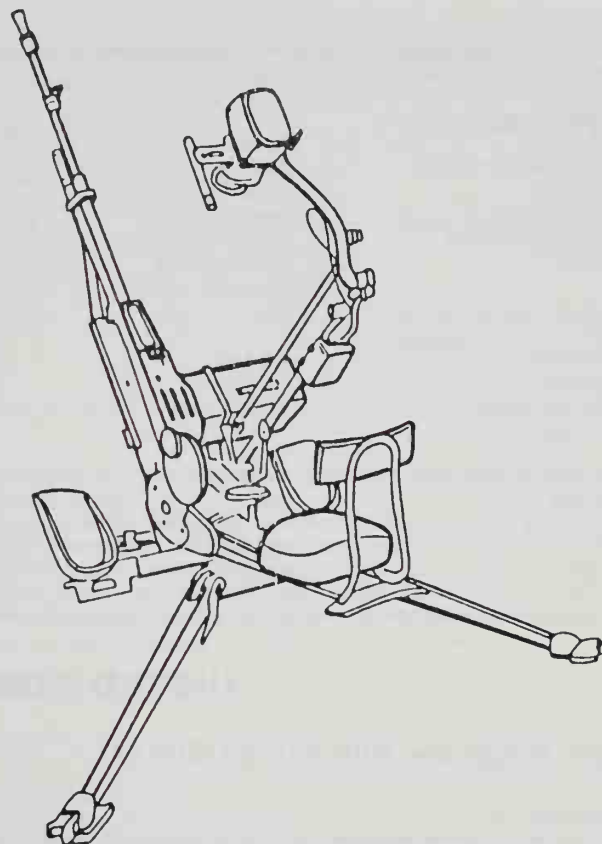


**SPECIFICATIONS** (12.7 mm NSV MG)

CALIBRE	12.7 mm
WEIGHT (without mount)	25 kg
OPERATION	gas, automatic
METHOD OF LOCKING	rotating bolt
LENGTH OVERALL	1.56 m
CYCLIC RATE OF FIRE	680/800 rpm
PRACTICAL RATE OF FIRE	80/100 rpm
SIGHTS	
aircraft targets	1500 m
ground targets	2000 m
MAXIMUM RANGE	6000 m
EFFECTIVE RANGE	1500/2000 m
MUZZLE VELOCITY	845 m/s

**Status:** The 12.7 mm NSV is widely used by countries that use the T-72 MBT. As far as it is known the anti-aircraft version is only used by the USSR.

**Manufacturer:** Soviet state factories.



*Tripod-mounted 12.7 mm NSV heavy anti-aircraft machine gun deployed in the firing position*

## UNITED KINGDOM

### 40 mm Automatic Anti-aircraft Gun Mk 1

#### Development

In 1937 the British Army placed an order with the Swedish Bofors company for a batch of 100 m/36 40 mm automatic anti-aircraft guns plus a large quantity of ammunition. Shortly afterwards a licence was obtained to undertake production of the weapon in the United Kingdom and additional weapons were ordered from Poland which was already producing the 40 mm for its own use and for export.

The 40 mm Bofors automatic anti-aircraft gun became the standard light anti-aircraft gun of the British Commonwealth during the Second World War and was also manufactured in Canada and in the USA where it was known as the 40 mm Automatic Anti-aircraft Gun M1 for which there is a separate entry in this section. The 40 mm gun was also used by the Royal Navy in both single and twin mounts the latter of which were normally water-cooled. The weapon was finally replaced in the British Army in the late 1950s by the 40 mm L/70 automatic anti-aircraft gun.

The original Swedish-designed carriage, designated the Mk 1 in British use, was too complicated to produce on a large scale so a new carriage

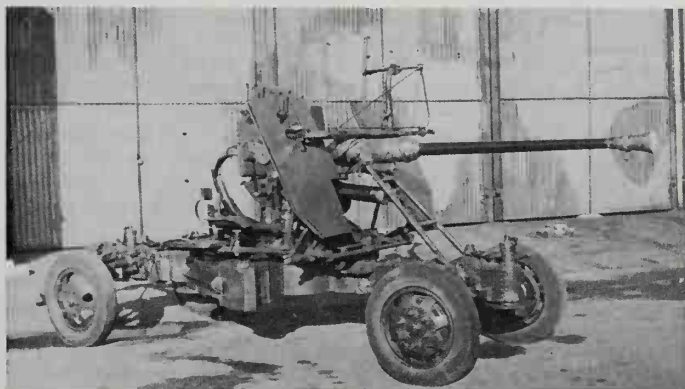
was designed called the Mk 2 with tubular rather than box type outriggers which was cheaper to manufacture. The Mk 3 carriage was almost identical to the Mk 2. Other more specialised carriages were developed but the Mk 2 and the Mk 3 were the most common and were distinguishable from American weapons by their longer carriage, tubular outriggers, rearward sloping shield and a vertical rather than angled travelling lock.

#### Description

In the firing position the wheels are normally removed and the carriage is supported on four jacks, one at each end of the carriage and one each side on outriggers. During the Second World War the 40 mm Bofors was normally used in conjunction with a No 3 (Kerrison) predictor. Ammunition is fed to the breech vertically in clips of four rounds and the empty cases are ejected under the forward part of the mount. The following types of ammunition can be fired:

AP with the projectile weighing 0.89 kg and a muzzle velocity of 853 m/s, which will penetrate 52 mm of armour at an incidence of 0° at a range of 457 m or 42 mm of armour at 0° at 914 m.

HE projectile weighing 0.9 kg with a muzzle velocity of 853 m/s.



*Original British 40 mm Bofors with riveted carriage and box type outriggers (via Terry J Gander)*



*British 40 mm Bofors with new carriage with tubular outriggers and different travelling lock for ordnance*

**Variant**

Details of the Royal Thai Air Force 20 mm systems based on a 40 mm carriage are given in this section under Thailand.

**SPECIFICATIONS**

CALIBRE	40 mm
BARREL LENGTH (overall)	2.249 m
OPERATION	recoil
RECOIL SYSTEM	hydro-spring
BREECH MECHANISM	vertical sliding block
CARRIAGE	4-wheeled with outriggers

SHIELD	yes
WEIGHT	
travelling order	2288 kg
firing position	2034 kg
LENGTH (travelling)	6.248 m
WIDTH (travelling)	1.92 m
HEIGHT (travelling)	2.438 m
ELEVATION/DEPRESSION	+90°/-10°
TRAVERSE	360°
RATE OF FIRE	
cyclic	120 rpm
practical	60 rpm

MAX RANGE	
horizontal	4750 m
vertical	4660 m
EFFECTIVE VERTICAL RANGE	2560 m
FEED	4-round clip
UNIT OF FIRE	200 rounds
CREW	4-6
TOWING VEHICLE	2½ t (6 × 6) truck

**Status:** Production complete. In service with a number of countries including:

Country	Quantity	User	Comment
Cyprus	20+	army	probably phased out of service
India	1245	army	used with Super Fledermaus FCS. may use US M1 rather than UK Mk 1
Pakistan	n/av	army	may be US M1 and not UK Mk 1
Yugoslavia	n/av	army	status uncertain, may be US M1 and not UK Mk 1

## UNITED STATES OF AMERICA

### 40 mm Automatic Anti-aircraft Gun M1

**Development**

Before the Second World War the USA made a number of unsuccessful attempts to obtain a Swedish Bofors 40 mm anti-aircraft gun which had already been adopted by the British Army. Late in 1940 Bofors guns were obtained by the Ordnance Department and the Bureau of Ordnance of the Navy.

Trials showed that the 40 mm gun was superior to the 37 mm anti-aircraft gun which had been adopted in 1940 and was already entering production by Colt's Patent Fire Arms Manufacturing Company. At that time the United States Army did not adopt the Bofors although production was allowed in the USA to meet British requirements. Late in 1941 the 40 mm Automatic Gun T1 and the 40 mm Automatic Gun Carriage T1 were standardised as the 40 mm Automatic Gun M1 and the 40 mm Automatic Gun Carriage M1 as the replacement for the 37 mm weapon. In February 1941 Chrysler was awarded a contract to build two guns and the Firestone Tyre and Rubber Company was awarded a contract for two carriages. The carriage was very complicated to manufacture so the company redesigned it for large-scale manufacture as the M2. By late 1941 the 40 mm Bofors was in production in the USA and first production weapons were delivered early in 1942.

Further development of the M2 carriage to increase the tracking rate and improve the outriggers and the sight resulted in the M2A1, and later other minor changes were made to both the carriage and the gun.

A special model for air transport called the M5 was developed but none are known to be in service today. Late in the Second World War the M19 twin 40 mm self-propelled anti-aircraft gun based on the chassis of the M24 light tank was developed but none remain in service today. The M19 was replaced in the early 1950s by the M42 self-propelled anti-aircraft gun, which is essentially the same turret as mounted on the M19 fitted to a new chassis which shares many common components with the M41 light tank. Full details of the M42 are given in the *Self-Propelled Anti-Aircraft Guns* section.

**Description**

In the firing position the carriage is supported on four jacks, one at the front and one at the rear, and one each side on outriggers. During the Second World War the 40 mm anti-aircraft gun was normally used in conjunction with the British-designed Kerrison predictor which was also manufactured in the United States by the Singer Manufacturing Company of Elizabethport, New York, under the designation M5. The following types of ammunition, which are fed to the breech vertically in clips of four rounds, could be fired: AP-T (M81 series) with the complete round weighing 2.077 kg, projectile weighing 0.89 kg and a muzzle velocity of 872 m/s. This will penetrate 52 mm of armour at an incidence of 0° at a range of 457 m, or 42 mm of armour at an incidence of 0° at a range of 914 m. HE-T with the complete round weighing 2.15 kg, projectile weighing 0.935 kg, muzzle velocity of 880 m/s. HEI-T with complete round weighing 2.15 kg and a muzzle velocity of 880 m/s. TP-T (M91) with the complete round weighing 2.14 kg and a muzzle velocity of 872 m/s.



40 mm anti-aircraft gun M1 of Brazilian Army in firing position with wheels raised and 4-round clip ammunition in position above breech (Ronaldo S Olive)

**SPECIFICATIONS**

CALIBRE	40 mm
BARREL LENGTH (overall)	2.49 m
OPERATION	recoil
RECOIL	hydro-spring
BREECH MECHANISM	vertical sliding block
CARRIAGE	4-wheeled with outriggers
SHIELD	optional
WEIGHT (travelling order)	2656 kg
LENGTH (travelling)	5.728 m
WIDTH (travelling)	1.829 m
HEIGHT (travelling)	2.019 m
GROUND CLEARANCE	0.359 m
TYRES	6.00 × 20
ELEVATION/DEPRESSION	+90°/-11°
TRAVERSE	360°
RATE OF FIRE	
cyclic	120 rpm
practical	60 rpm
MAX RANGE	
horizontal	4753 m
vertical	4661 m
EFFECTIVE VERTICAL RANGE	2742 m
FEED	4-round clip
UNIT OF FIRE	200 rounds
CREW	4-6
TOWING VEHICLE	2½ t (6 × 6) truck



**Status:** Production complete. In service with many countries including

Country	Quantity	User	Comment	Country	Quantity	User	Comment
Argentina	80	army		Korea, South	80+	army	
Brazil	60	army		Peru	28	army	
Burma	10	army	status uncertain	Norway	132	army	may be in reserve, 32 Air Force
Colombia	30	army		Pakistan	60	army	
Dominican Republic	20	air force		Paraguay	12	army	
Ecuador	30	army		Portugal	20-30	army	may be Swedish L/60
Greece	230	army	some now in reserve	Taiwan	200	army	
Guatemala	12	army		Thailand	80	army	
India	1245	army	used with Super Fledermaus FCS, may use UK Mk 1 rather than M1	Turkey	300	army	
Iran	20-40	army	also used by Air Force, status uncertain	Yugoslavia	128	army	may be UK Mk 1, status uncertain

## M167 20 mm Vulcan Anti-aircraft Gun

### Development

Development of the Vulcan Air-Defense system began under the direction of the United States Army Weapons Command at Rock Island Arsenal, Illinois, in 1964. Two versions of the Vulcan were subsequently developed; a self-propelled model called the M163 (development designation XM163) and a towed model called the M167 (development designation XM167). Prime contractor for both models is the Armament Systems Department of the General Electric Company of Burlington, Vermont.

After trials carried out by the United States Army Air Defense Board at Fort Bliss, Texas and at Aberdeen Proving Ground, Maryland, in 1965, the system was accepted for service as the replacement for the 12.7 mm (quad) M55 anti-aircraft gun system. First production M167s were delivered to the United States Army in 1967 and since then the system has been adopted by a number of other countries. The current service model is the M167A1 which incorporates no fundamental changes from the M167. By early 1988 a total of 626 M167s had been built and production had been completed. It can be resumed if further orders are placed.

The M167 is deployed in the United States Army with the airborne and airmobile division, each of which has one battalion of M167s consisting of an HQ and HQ battery and four batteries. Each battery has a battery HQ and three firing platoons each with four M167 systems, giving the battalion 48 Vulcan weapons.

In 1991 it was stated that the US Army will phase out these systems by 1994 with its replacement being the Boeing Avenger (4 × 4) SAM system already in volume production.

### Description

The towed version of the Vulcan air-defence system is mounted on the M42A1 two-wheeled carriage and is a lightweight version of the M163 self-propelled system which is fully described in the *Self-Propelled Anti-Aircraft Guns* section. The M167 has the advantage of being helicopter transportable and can therefore be used in tactical situations where the tracked version cannot be employed.

The M167 consists of a 20 mm Vulcan gun, linked ammunition feed system and a fire control system, all mounted in an electrically powered turret. The towed M42A1 carriage has its own power generator for recharging mounted on the forward part of the carriage.

The six-barrelled 20 mm M168 cannon has two rates of fire, 1000 rds/min, normally used against ground targets and 3000 rds/min, normally used against aircraft. Maximum effective anti-aircraft range is 1200 m and maximum effective ground range is 2200 m. The gunner can select either 10-, 30-, 60- or 100-round bursts (in the high rate of fire only) and the dispersion pattern can be increased by fitting a special muzzle spread which results in an increased hit probability. The ammunition container is on the left side and holds 300 or 500 rounds of ammunition. The 20 mm M168 cannon can fire the following types of fixed ammunition:

M53 (APT) with the projectile weighing 0.1 kg and a muzzle velocity of 1030 m/s.

M54 (HPT) with the projectile weighing 0.127 kg.

M55A2 (TP) with the projectile weighing 0.098 kg and a muzzle velocity of 1030 m/s.

M56A3 (HEI) with the projectile weighing 0.103 kg and a muzzle velocity of 1030 m/s.

M220 (TPT) with the projectile weighing 0.097 kg and a muzzle velocity of 1030 m/s.

M242 (HEIT) with the projectile weighing 0.094 kg and a muzzle velocity of 1030 m/s.

The system has five modes of operation: radar, manual, ground, external or test. The first of these is the normal operational mode with the 5000 m range radar determining the target range and range rate. The fire control computer computes the predicted target flight path, positions the cannon in superelevation and azimuth to achieve target impact, ramps in rate aid to

take over track from the gunner and stabilises the sight graticule in the target line-of-sight.

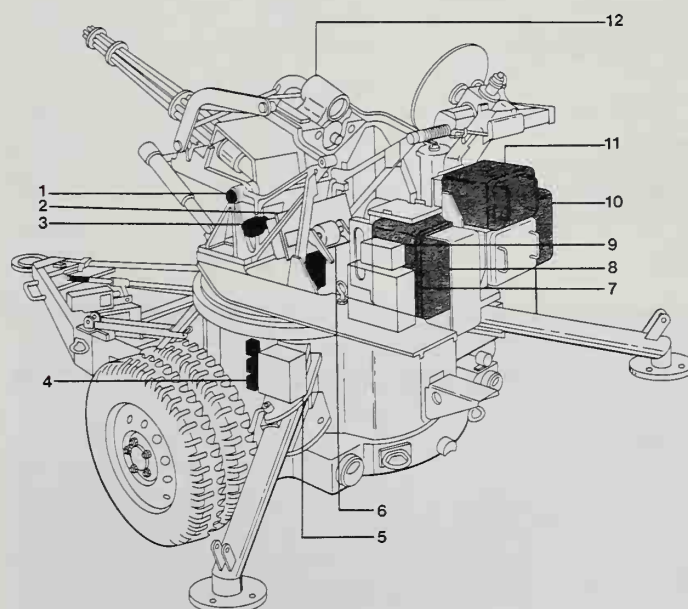
The ready to fire indicator lamp on the sight lights up when the fire control computer determines that all conditions are satisfied. These conditions are; predicted impact is within ammunition range, lead angle is less than 25°, elevation angle is less than 80°, radar is locked on and rate aid starts.

When deployed in the firing position, the M167 is stabilised by three jacks, one at the front and one either side on outriggers.

### Variants

### PIVADS

Lockheed Canada Inc is marketing an improved fire control system for the Vulcan system which includes a new optical sight, a digital processor and harmonic drives for azimuth and elevation. A director-type optical sight is provided as the angle tracking device, which permits rapid acquisition and accurate tracking when turret disturbances are present. The sight contains integrating rate gyros for azimuth and elevation tracking, in conjunction with proportional hand-grip controls. A new digital processor replaces the existing analogue computer to improve weapon tracking and operational capabilities. The system also includes built-in test equipment and permits multiple ballistics selection via the operator control panel. System response and point accuracies are also improved with the new Lockheed Canada system. Harmonic drives replace older azimuth and elevation gear trains to improve stiffness, backlash and power consumption characteristics. A test prototype, designated Product Improved Vulcan Air Defense System (PIVADS) was tested extensively by the US Army at Fort Bliss in June 1979. Late in 1982 the US Army awarded Lockheed Electronics a \$19 million contract for the supply of 285 PIVADS kits for the 20 mm Vulcan Air Defense System in both towed and self-propelled configurations. Of the 285 systems, 122



Key components of Lockheed Canada Product Improved Vulcan Air Defense System (PIVADS) are (1) Elevation synchro (2) Control panel (3) Elevation drive (4) Servo amplifiers (three) (5) Distribution box (6) Azimuth drive (7) Electronics unit (8) Radar power supply (9) Voltage converter (10) Radar unit 2 (11) Radar unit 4 (12) Director gunsight

were for the towed M167 series and the remaining 163 for the M167 self-propelled systems. In 1990 all manufacturing pertaining to this system was transferred to Lockheed Canada Inc, in Ottawa, Ontario. The company, a part of the Lockheed Electronics Systems Group, was then awarded its first PIVADS contract for \$4.2 million to supply spares to the US Army.

### Basic Vulcan

This is a simplified version of the M167 Vulcan produced for commercial export sales. The basic changes are to the fire control system which does not use the range-only radar of the M167 but a range update computer, lead-computing gunsight and a control panel which includes burst length, estimated range and target speed settings, mode selection, and controls for positioning the electrically powered turret.

Four operating modes are available to the gunner, range update, external range, fixed mode and ground.

With range update the gunner identifies the target visually, estimates the target speed, selects the burst length and predicted range at which he intends to open fire. These settings are made on the control panel. Using the hand controls he moves the turret to acquire the target in the sight, keeping the sight gyro caged by using a button on the left-hand grip. On acquisition, he releases the cage button and tracks the target using the centre of the sight graticule. After tracking the target to the preselected range the gunner opens fire. The computer then updates the range data automatically and supplies the system with the lead angles and superelevation throughout the engagement.

In the external range mode an extra crew member signals the predicted range and signals the gunner to open fire. The extra crew member then updates the range setting via a hand-held external range unit.

In the fixed mode the lead computing gun sight is fixed with preset range and target speed.

In the ground mode the lead computing sight is mechanically caged so that the system is set for use at 1000 m range.

The rest of the Basic Vulcan is the same as the normal M167. The only data change is that the combat weight is reduced to 1406 kg.

### Dual Wheel Vulcan

All US Army M167 Vulcans have been modified by the addition of a second road wheel on each side of the carriage. This increases cross-country performance. The extra wheel is available as a modification kit, and when fitted the combat weight of the M167A1 is increased to 1732 kg. The outside wheel track is then 2.271 m and the inside track 1.76 m.

#### SPECIFICATIONS

CALIBRE	20 mm
BARREL LENGTH	1.524 m
OPERATION	externally powered
CARRIAGE	2-wheeled with outriggers
SHIELD	no
WEIGHT	
travelling order	1588 kg
firing position	1565 kg
LENGTH (travelling)	4.906 m
WIDTH (travelling)	1.98 m
HEIGHT	
travelling	2.038 m
firing	1.651 m
TRACK	1.752 m
ELEVATION/DEPRESSION	+80°/-5°
TRAVERSE	360°
CYCLIC RATE OF FIRE	
low	1000 rpm
high	3000 rpm



Basic Vulcan with dual wheels deployed in firing position

#### MAX EFFECTIVE RANGE

anti-aircraft	1200 m
ground	2200 m
CREW	1 (on mount)
TOWING VEHICLES	4 × 4 or 6 × 6 truck

Status: Production as required. In service with:

Country	Quantity	User	Comment
Belgium	36	army	without radar
Botswana	n/av	army	small number delivered from US in 1989
Ecuador	28	army	
Israel	100	air force	airfield defence
Jordan	100	army	
Korea, South	66+	army	has been built locally
Morocco	70	army	delivered early 1980s
Somalia	n/av	army	
Sudan	n/av	army	
USA	220	army	122 upgraded with PIVADS, to be phased out of service in 1994
Uruguay	6		

**Manufacturers:** Armament Systems Department, General Electric Company, Lakeside Avenue, Burlington, Vermont 05401-4985, USA.  
Telephone: (802) 657-6000  
Telex: 510 299 0028

Daewoo Heavy Industries Limited, 6 Manseog-Dong, Dong-Gu, Incheon, South Korea.  
Telephone: (132) 72-1011  
Telex: K23301

## 12.7 mm (Quad) Anti-aircraft Machine Gun M55

#### Development

Development of the 12.7 mm (0.50) (Quad) Anti-aircraft Machine Gun M55 was begun in 1942 by the Kimberly-Clark Corporation and it entered service the following year. About 10 000 M55s were delivered to the US Army between 1943 and 1953, with the final contractor being the Bowen and McLaughlin Corporation. It has been replaced in the United States Army by the 20 mm M167 Vulcan anti-aircraft gun system.

#### Description

The full designation of the M55 is the Mount, Gun, Trailer, Multiple Calibre .50 Machine Gun, M55 and is composed of two main parts; the M45C Mount and the M20 Trailer.

The M45C Mount is a power-driven semi-armoured gun mount with a self-contained power unit. A power charger produces electrical current to

be stored in two 6 V storage batteries on which the electrical system operates. The mount has four 12.7 mm (0.50) M2 HB machine guns, two each side. The early models have two M2 ammunition chests each side, but later mounts have the chests replaced by ammunition box trays.

Power is directed by a pair of control handles immediately in front of the operator's seat on the mount. The machine guns are fired by a solenoid and will continue to fire and load automatically as long as the gunner applies pressure to both the triggers on the control handles.

The gunner aims the weapons using an M18 reflex sight which projects a graticule image, focused at infinity, on an inclined glass plate. The graticule image consists of four concentric circles, corresponding to various aircraft speeds, and three dots on a vertical line in the centre of the field-of-view are used to determine line-of-sight and to compensate for gravity pull on the projectile. As the gunner looks through the plate he sees the target superimposed on the graticule image. Turret traverse and gun elevation speeds are 60°/s.





12.7 mm (Quad) anti-aircraft machine gun M55 in firing position (US Army)



M16 half-track armed with four 12.7 mm anti-aircraft machine guns. When deployed for firing the upper parts of the hull-sides fold downwards to give the weapons all round traverse (Kensuke Ebata)

The machine guns fire the following types of fixed ammunition:

Type	Designation	Projectile Weight	Muzzle velocity
AP	M2	45.88 or 46.53 g	885 m/s
API	M8	42.06 g	888 m/s
API-T	M20	39.66 g	888 m/s
Ball	M2	46.1 or 46.79 g	858 m/s
Ball	M33	42.9 g	888 m/s
Incendiary	M1	41.02 g	901 m/s
Incendiary	M23	33.18 g	1036 m/s
Training	M10	41.67 g	873 m/s
Training	M17	14.67 g	873 m/s
Training	M21	45.3 g	867 m/s

In the firing position the wheels are removed by using the three lifting jacks (one at the front and two at the rear of the carriage) and the complete unit is then lowered to the ground to provide a stable firing platform. The two-wheeled trailer M20 can be towed by a light 4 x 4 Jeep-type vehicle, but its small diameter tyres allow it to be towed on roads at a maximum speed of only 16 km/h. Normally the trailer is carried in the rear of a 2½ t (6 x 6) truck which is equipped with special loading and unloading equipment.

#### Variants

During the Second World War the M45 Mount was mounted on Trailer Mount M17 which in turn was mounted on the M51 four-wheel carriage, which could be towed by a 4 x 4 or 6 x 6 truck. Two self-propelled models were also built, the M16 which was based on the M3 half-track and the M17 based on the M5 half-track.

The MBT Division of Israel Aircraft Industries has developed a new model armed with twin 20 mm cannon called the TCM-20, details of which are given in this section under Israel.

Brazil has developed a modernised version of the M55. See entry under Brazil in this section.

In 1989 GIAT Industries of France announced that it had, as a private venture, modernised a M16 half-track self-propelled anti-aircraft gun system. The four 12.7 mm machine guns have been replaced by two GIAT Industries 20 mm cannon with the gun control and sighting systems also being improved. Trials of the prototype system were carried out in 1989.

#### SPECIFICATIONS

CALIBRE	12.7 mm
BARREL LENGTH	1.143 m
MUZZLE BRAKE	none
OPERATION	recoil, automatic
CARRIAGE	2-wheeled
SHIELD	yes
WEIGHT	
travelling order with trailer	1338 kg
firing position	975 kg (M45C only)
LENGTH (travelling)	2.89 m
WIDTH (travelling)	2.09 m
HEIGHT	
travelling	1.606 m
firing	1.428 m
GROUND CLEARANCE	
(travelling)	0.178 m
TRACK	1.524 m

ANGLE OF APPROACH/DEPARTURE	10°/20°
FORDING	0.457 m
ELEVATION/DEPRESSION	+90°/-10°
TRAVERSE	360°
RATE OF FIRE PER BARREL	
cyclic	450/550 rpm
practical	150 rpm
EFFECTIVE RANGE	
horizontal	1500 m
vertical	1000 m
FEED (per barrel)	210-round belt
CREW	4 (1 on mount)
TOWING VEHICLE	4 x 4 Jeep (normally carried on rear of 6 x 6 truck)

Status: Production complete. In service with the following countries:

Country	Quantity	User	Comment
Brazil	n/av	army	some locally modified (qv)
Chile	n/av	army	
Denmark	n/av	army	also Air Force for airfield defence
Italy	109	army	status uncertain
Japan	280	army	some also used for airfield defence
Jordan	36	army	
Korea, South	n/av	army	locally built, also truck-mounted
Mexico	40-50	army	
Norway	n/av	army	some used for air defence
Pakistan	45	army	
Portugal	18	army	
Spain	132	army	also Marines, some truck-mounted
Thailand	n/av	army	
Turkey	160	army	



M16 half-track modernised by GIAT Industries with four 12.7 mm machine guns being replaced by two GIAT Industries 20 mm cannon

## YUGOSLAVIA

## 20/3 mm M55 A2 Anti-aircraft Gun

## Development

The 20/3 mm M55 A2 anti-aircraft gun forms the 'base' component of a family of three similar weapons all based on the same triple-gun mounting; the other two weapons are the M55 A3 B1 and the M55 A4 B1 (see following entries). The first 20/3 mm M55 guns were produced in 1955.

## Description

Although many local modifications have been introduced since 1955, the 20/3 mm M55 A2 is basically a licence-built weapon comprising three Hispano-Suiza HSS-804 20 mm L/70 guns mounted on the HSS 630-3 towed carriage. The three guns are arranged on the mounting horizontally with the central gun positioned slightly to the rear of the two outboard guns; this allows the three 60-round drum magazines to be positioned close together for loading, and concentrates the three barrels. In action the carriage rests on three outrigger legs that are folded outwards into place, with the two carriage wheels raised off the ground. In an emergency the guns can be fired directly from the towed carriage. A spring suspension is used on the carriage which is equipped with a hydraulic system for the parking and automatic towing brakes. The weapon can be towed at speeds of up to 80 km/h by a light 4 × 4 truck.

The gunner, positioned behind the guns, aims manually with elevation and traverse handwheels and fires via a foot pedal. Two equilibrators are provided. For fire control the M55 A2 is fitted with a PANS-20/3 optical-mechanical automatic sight. The gunner inserts the target information which includes target range, course angle, angles of dive and climb, and

target speed which is inserted in increments of 50 m up to 300 m/s. With the target information inserted the gunner can then track the target directly using the sight graticule. Targets flying at speeds up to 1000 km/h can be engaged at ranges up to 1500 m although for slower targets the effective range is 2000 m.

The ammunition used with the M55 gun family includes the following types:

TYPE	HEI-T	HE-T	HEI	HE	API	API-T	AP-T
DESIGNATION	M57	M57	M57	M57	M60	M60	M60
WEIGHT OF PROJECTILE	137 g	137 g	132 g	132 g	142 g	142 g	142 g
TYPE OF BURSTING CHARGE	TNT or RDX/ Alum	TNT or RDX/ Alum	TNT+ Inc	TNT or RDX/ Alum	nil	nil	nil
TOTAL WEIGHT OF ROUND	261 g	261 g	257 g	257 g	274 g	274 g	274 g
MUZZLE VELOCITY	850 m/s	850 m/s	850 m/s	850 m/s	840 m/s	840 m/s	840 m/s

Additional rounds include TP-T (M57), TP-T (M79), TP (M57), Blank (M77) and drill.

All of the above have brass cartridge cases 110 mm long with propellant being NC powder.

## SPECIFICATIONS

CALIBRE	20 mm
BARREL LENGTH	1.956 m
CARRIAGE	2-wheeled
SHIELD	no
WEIGHT	
with loaded drums	1100 kg
with empty drums	970 kg
LENGTH (travelling)	4.3 m
WIDTH (travelling)	1.27 m
HEIGHT (gun, travelling)	1.47 m
GROUND CLEARANCE	0.23 m
ELEVATION/DEPRESSION	+83°/-5°
TRAVERSE	360°
RATE OF FIRE PER BARREL (cyclic)	700 rpm
RATE OF FIRE (total, cyclic)	2100 rpm
FEED (per barrel)	60-round drum magazine
MAX RANGE	
horizontal	5500 m
vertical, under 80°	4000 m
EFFECTIVE RANGE	
horizontal	2500 m
vertical	2000 m
CREW	6
TOWING VEHICLE	TAM 110 T7BV (4 × 4) truck

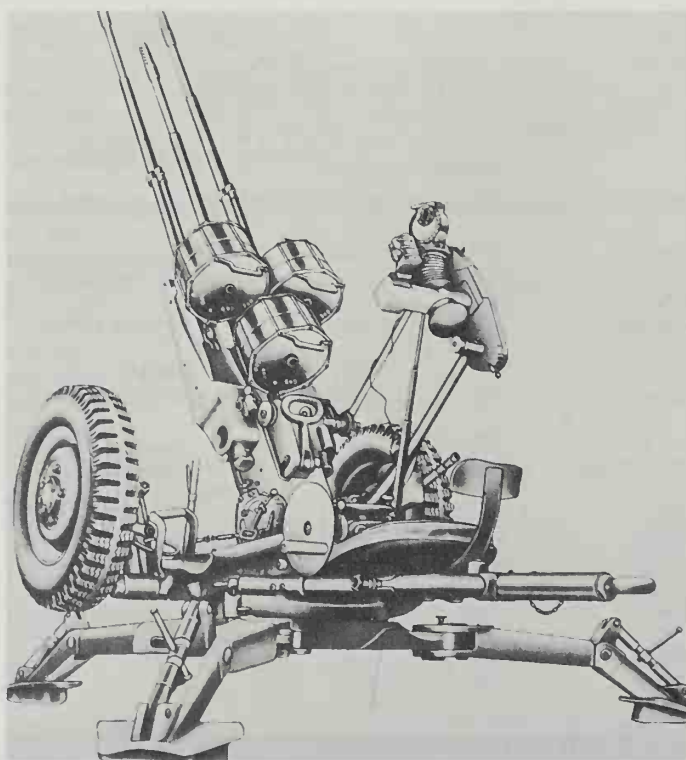
**Status:** Production as required. In service with Angola, Cyprus, El Salvador, Honduras, Lebanon, Mozambique, Yugoslavia, Zimbabwe, United Arab Emirates and possibly some other countries.

**Contractor:** Federal Directorate of Supply and Procurement (SDPR), PO Box 308, 9 Nemanjina Street, YU-11105 Beograd, Yugoslavia.

Telephone: 621 522

Telex: 11360

Fax: 635 702



20/3 mm M55 A2 anti-aircraft gun in firing position



## 20/3 mm M55 A3 B1 Anti-aircraft Gun

### Development/Description

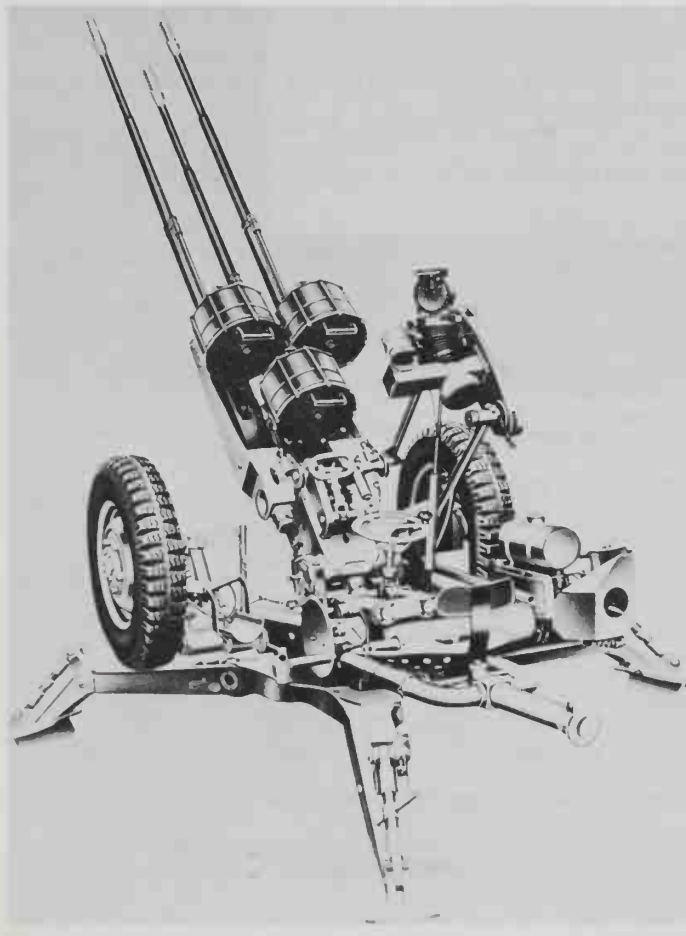
The 20/3 mm M55 A3 B1 anti-aircraft gun is a Yugoslavian-derived variant of the basic M55 A2 weapon. It uses the same locally produced Hispano-Suiza HSS-804 20 mm L/70 guns in a triple arrangement and the carriage is derived from the HSS 630-3. The main change on the M55 A3 B1 is that a small Wankel engine has been added to the right of the gunner's position to provide power for both elevation and traverse.

The Wankel engine has a power output of 8 hp. Each chamber has a capacity of 160 cm<sup>3</sup> and consumes, on medium load, 2.4 litres of fuel an hour (the petrol/oil mix is 50:1). The power unit has three main components; the control unit which the gunner operates via a single joystick for both traverse and elevation, the transmission system and the Wankel engine. In traverse the power unit can move the carriage at rates between 0.3 and 70°/s. In elevation the barrel can be moved at rates between 0.3 and 50°/s. Manual control is available.

In all other respects the M55 A3 B1 is the same as the M55 A2 and uses the same PANS-20/3 sighting system and ammunition types (qv). The only change is that the weight without the ammunition drums is 1150 kg and with all three loaded drums fitted the weight is 1235.5 kg.

**Status:** Production as required. In service with Yugoslavia.

**Contractor:** Federal Directorate of Supply and Procurement (SDPR), PO Box 308, 9 Nemanjina Street, YU-11105 Beograd, Yugoslavia.  
Telephone: 621 522  
Telex: 11360  
Fax: 635 702



*20/3 mm M55 A3 B1 anti-aircraft gun in firing position*

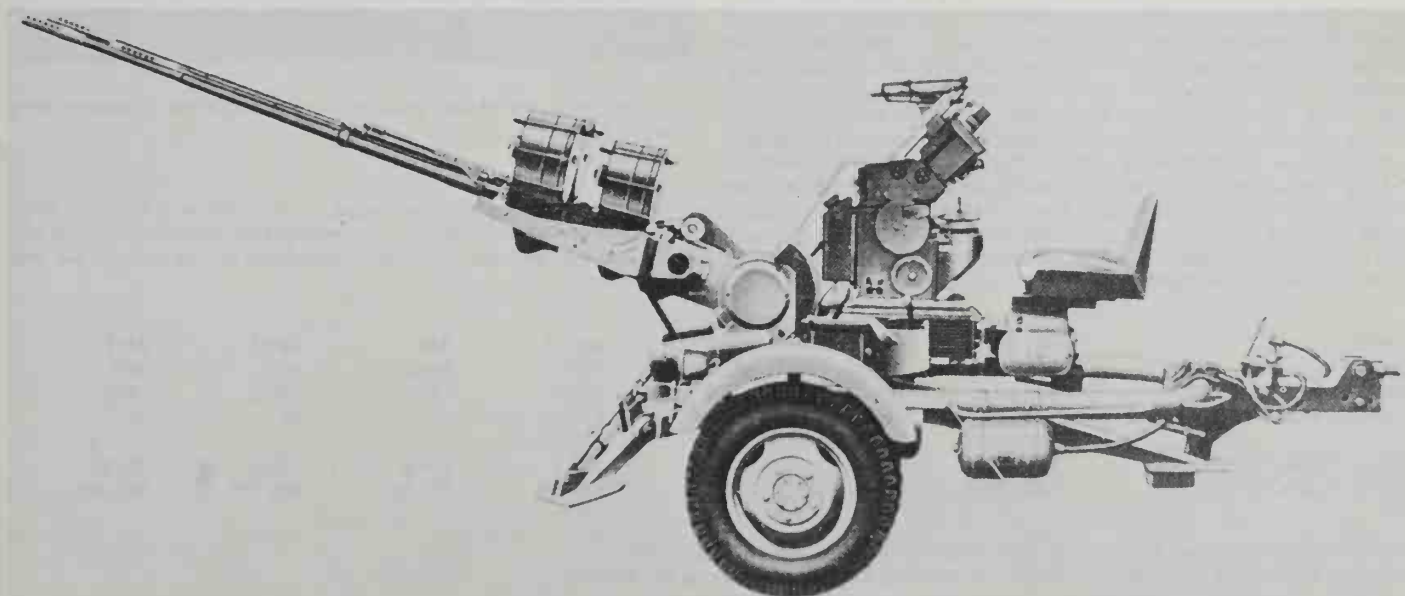
## 20/3 mm M55 A4 B1 Anti-aircraft Gun

### Development/Description

With the 20/3 mm M55 A4 B1 the Yugoslavian weapon designers have combined the established M55 triple-gun mounting with a local adaptation of the carriage and sighting system of the Hispano-Suiza HSS 666A (now the Oerlikon twin 20 mm GAI-D01 automatic anti-aircraft gun). While the three licence-built HSS-804 20 mm barrels have been retained, the M55 carriage has been much revised to accommodate a Wankel engine under the gunner's seat, a licence-built version of the Italian Officine Galileo P56 computer sight, a small shield and a compressed air system for firing the guns. The engine provides the power for a hydraulic drive system to move

the carriage in both elevation and traverse. In action the maximum rate of motion of the carriage in both modes is up to 80°/s. Acceleration in traverse is 120°/s<sup>2</sup> and in elevation 60°/s<sup>2</sup>.

Before the computer sight is used the target range and speed are inserted into the sight computer, the latter in speeds of up to 350 m/s, while the maximum range which can be inserted is 1200 m. The computer sight will then lay off automatically for traverse and angle of lead (up to 21°). The gunner controls the weapon aim by a joystick mounted on the console under the sight unit. For ground targets, the sight unit uses a separate sight with range divisions of 100 to 2500 m. The ground sight has a magnification of  $\times 4$  (the aircraft sight has a magnification of  $\times 1.1$ ). For rough alignment of the barrels with a target the gunner uses an open horizontal grid sight



*20/3 mm M55 A4 B1 anti-aircraft gun in travelling position*

## 220 TOWED ANTI-AIRCRAFT GUNS / Yugoslavia

over the sight unit. Once the gun is roughly aligned he then uses the optical system of the computer sight.

The maximum towing speed of the M55 A4 B1 is 70 km/h.

The ammunition types used with the M55 A4 B1 are the same as those used with the M55 A2 (qv).

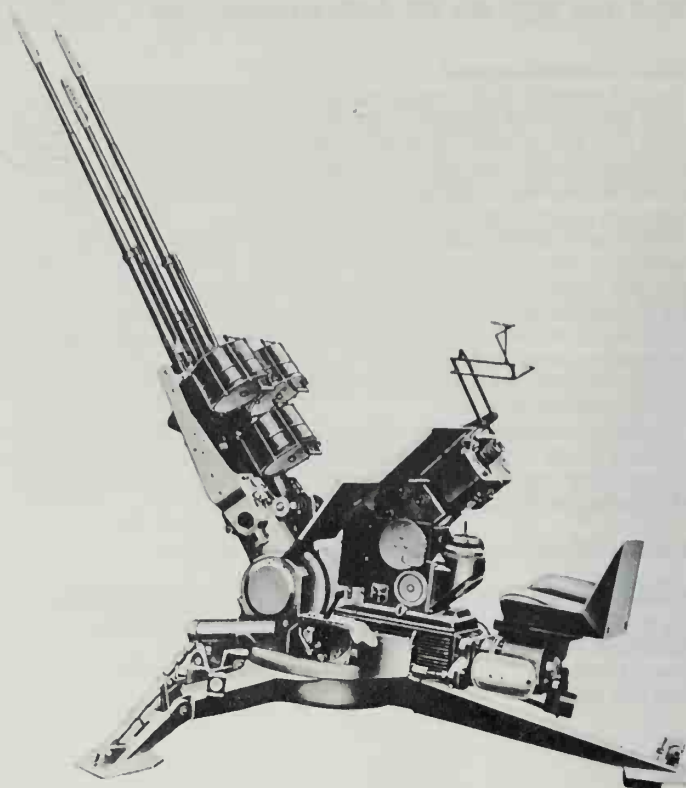
The BOV-3 triple 20 mm self-propelled anti-aircraft gun system uses the 20/3 mm M55 A4 B1 system on a 4 × 4 armoured chassis. Details of this are given in the *Self-Propelled Anti-Aircraft Guns* section.

### SPECIFICATIONS

CALIBRE	20 mm
BARREL LENGTH	1.956 m
CARRIAGE	2-wheeled
SHIELD	yes
WEIGHT	
travelling, less drums	1350 kg
in action loaded	1095.5 kg
carriage	300 kg
ELEVATION/DEPRESSION	+83°/-5°
TRAVERSE	360°
RATE OF FIRE PER	
BARREL (cyclic)	700 rpm
FEED (per barrel)	60-round drum magazine
MAX RANGE	
horizontal	5500 m
vertical, under 80°	4000 m
EFFECTIVE RANGE	
horizontal	2500 m
vertical	2000 m
CREW	6
TOWING VEHICLE	TAM 110 T7BV (4 × 4) truck

**Status:** Production as required. In service with Yugoslavia.

**Contractor:** Federal Directorate of Supply and Procurement (SDPR), PO Box 308, 9 Nemanjina Street, YU-11105 Beograd, Yugoslavia.  
Telephone: 621 522  
Telex: 11360  
Fax: 635 702



20/3 mm M55 A4 B1 anti-aircraft gun in firing position

## 20/1 mm M75 Anti-aircraft Gun

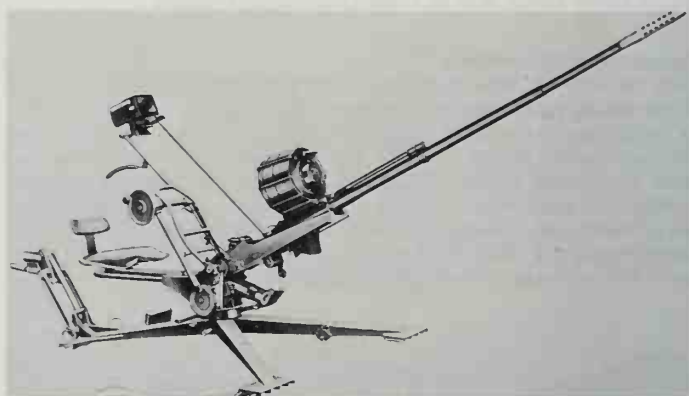
### Development

The 20/1 mm M75 anti-aircraft gun is a simple lightweight weapon mounting a single license-produced HSS-804 20 mm L/70 gun and is intended for infantry use against both air and ground targets.

### Description

The M75 is transported on a two-wheeled bogie which also carries ammunition and sight boxes. In action, the M75 can be emplaced by two men and when the bogie is removed the gun rests on a tripod mounting with the actual carriage height being varied by the mounting feet angles; the rear tripod leg foot angle adjustment doubles as a variable height towing eye. For traverse the gunner pushes the gun round with his feet but for elevation a small handwheel is provided. The M75 is light enough to be carried in or on vehicles but can be stripped down for pack carriage on four animals in only 60 seconds. As the heaviest subassemblies weigh no more than 55 kg, manpack carriage is possible. Assembly and disassembly require no tools. The M75 may be fired direct from the bogie if necessary.

The M75 can be fitted with a simple cartwheel sight for anti-aircraft use but the more usual sight is the M73, a reflex sighting device with a tritium source providing scale illumination. The M73 is calibrated for an average target range of 800 m and target speeds of 50, 100, 150, 200, 250 and 300 m/s, it uses an elliptical grid. For use against ground targets at ranges up to 1000 m a × 3.8 magnification sighting telescope is used.



20/1 mm M75 anti-aircraft gun, with drum magazine, in normal firing position

The normal ammunition feed used on the M75 is a 60-round drum magazine but when using armour-piercing ammunition a 10-round box magazine may be used. The same ammunition as that used on the M55 family is fired:

TYPE	HEI-T	HE-T	HEI	HE	API	API-T	AP-T
DESIGNATION	M57	M57	M57	M57	M60	M60	M60
WEIGHT OF PROJECTILE	137 g	137 g	132 g	132 g	142 g	142 g	142 g
TYPE OF BURSTING CHARGE	TNT or RDX/Alum	TNT or RDX/Alum	TNT + Inc	TNT or RDX/Alum	nil	nil	nil
TOTAL WEIGHT OF ROUND	261 g	261 g	257 g	257 g	274 g	274 g	274 g
MUZZLE VELOCITY	850 m/s	850 m/s	850 m/s	850 m/s	840 m/s	840 m/s	840 m/s

Additional rounds include: TP-T (M57), TP-T (M79), TP (M57), Blank (M77) and drill.

All of the above have brass cartridge cases 110 mm long with propellant being NC powder.



**SPECIFICATIONS**

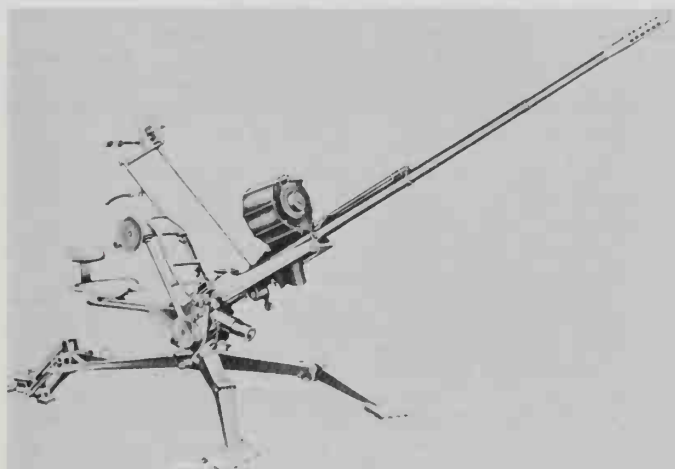
CALIBRE	20 mm
BARREL LENGTH	1.956 m
CARRIAGE	2-wheel bogie/tripod
SHIELD	no
WEIGHT (total)	260 kg
WIDTH	1.51 m
TRACK WIDTH	1.215 m
GROUND CLEARANCE (bogie)	0.215 or 0.315 m
ELEVATION/DEPRESSION	+83°/-10°
TRAVERSE	360°
RATE OF FIRE (cyclic)	700 rpm
FEED	60-round drum or 10-round box magazine
MAX RANGE	
horizontal	5500 m
vertical, under 80°	4000 m
EFFECTIVE RANGE	
aerial targets	2000 m
ground targets	1000 m plus
CREW	4-6
TOWING VEHICLE	light 4 × 4 truck or pack carriage

**Status:** Production as required. In service with Yugoslavia and Zambia.

**Contractor:** Federal Directorate of Supply and Procurement (SDPR),  
PO Box 308, 9 Nemanjina Street, YU-11105 Beograd, Yugoslavia.  
Telephone: 621 522  
Telex: 11360  
Fax: 635 702



*20/1 mm M75 anti-aircraft gun in travelling position*



*20/1 mm M75 anti-aircraft gun with carriage legs raised and fitted with drum magazine*

# Towed Anti-Aircraft Gun Sights

## FRANCE

### SAGEM SAS 90 Anti-aircraft Fire Control System

#### Development/Description

The SAS 90 is a low-cost anti-aircraft fire control sighting system which has been developed by SAGEM as a private venture. It is a modular system that can be installed on small and medium calibre gun mounts, naval gun mounts (where the SAS 90 can also provide stabilisation), cupolas for small and medium calibre guns and anti-aircraft missile mounts.

It incorporates a continuously variable projected graticule connected to a camera for automatic tracking, distance measurement and lead angle computation. It is fixed directly onto existing gun mounts and facilitates tracking by improving firing accuracy, so giving the weapon a higher hit capability.

The SAS 90 anti-aircraft fire control system comprises:

- (1) a sight display assembly which is equipped with a LCD matrix with a collimator for projection of generated images which are overlayed on the landscape. The graticule's size and position are variable and a gyro measures the line-of-sight orientation
- (2) an automatic tracking rangefinding CCD camera which has been designed for high temperature operation. The picture is directly digitised, which simplifies image processing and also ensures a high quality
- (3) an electronic unit for symbol and graticule generation for the LCD display, tracking and ranging based on CCD camera images, lead angle computation, firing calculations and data transmission outside of the system
- (4) an optional low-cost FLIR giving the system all-weather and night capabilities.

Basic specifications are:

Sight: direct view;  $20^\circ \times 20^\circ$  field-of-view; projected graticule with continuously variable size and position; standby graticule; direction measurement by gyro or potentiometer CCD camera; two automatic fields-of-view:  $32 \text{ mrad (V)} \times 39 \text{ mrad (H)}$ ,  $64 \text{ mrad (V)} \times 78 \text{ mrad (H)}$ ; resolution 500 pts/line; sensitivity 1 lux; digital and/or CCIR output.

Fire Control: high evolutive targets; overall accuracy 2 mrad; built-in test equipment.



*SAGEM SAS 90 anti-aircraft fire control system*

IR Camera (optional): wavelength 8 to  $12 \mu\text{m}$ ; detection range 5000 m; 2 fields-of-view.

Status: Pre-production.

Manufacturer: SAGEM, 27 rue Leblanc, Le Ponant de Paris, F-75512 Paris Cedex 15, France.

Telephone: (1) 40 70 63 63

Telex: 205 255 F

Fax: (1) 40 70 66 40

## ITALY

### Officine Galileo P56 Optical Sight and Fire Control System

#### Development

In 1960 Officine Galileo started development work on a new anti-aircraft fire control system called the P36. Development was completed in 1962, with first production systems being completed in 1963 and a total of 800 units were subsequently built before production ended.

The P36 was replaced by the P56, on which development work commenced in 1970. Development was completed in 1972 and production commenced the same year. By 1991 a total of 3800 units had been completed. Further development of the P56 has resulted in the Galileo Vanth MA and MB systems for which there are separate entries.

#### Description

The P56 is a computing sight designed for installation on light anti-aircraft guns to enable them to engage accurately low and very low flying targets attacking at high speed (up to 350 m/s). In addition it is suitable to engage ground targets at a range of up to 4000 m.

The P56 has been installed on a wide range of weapons including GIAT Industries twin 20 mm 76T2, Bofors 40 mm L/60, Oerlikon-Contraves GAI-D02, Rheinmetall Rh 202, Dassault Electronique twin 20 mm turret on Panhard M3 (4 x 4) chassis and on some Yugoslav 20 mm weapons.

The P56 system is directly mounted on the gun and as it has its own power supply, it is a fully autonomous weapon.

The P56 comprises an open sight for the acquisition of the target, an optical sight for tracking, a joystick, a panel on which the estimated parameter

of target speed and crossing range are introduced to feed the computer, an electronic computer for continuous computation of lead angles, both in azimuth and elevation and an AC generator which is driven by an engine mounted under the gunner's seat.

With an optional kit, crossing range is automatically computed and as a consequence, only one parameter - the speed of the target - must be estimated and introduced.

The gunner tracks the target in the centre of the graticule by moving the joystick, and the computer controls both the line-of-sight and the line-of-fire, computing the lead angles continuously. The target is aligned with the centre of the graticule, while the gun is aiming at the future intercept point.

A typical target engagement sequence is as follows. The gunner estimates the target parameters and acquires the target. Target parameters are introduced into the P56; he then tracks the target and opens fire.

#### SPECIFICATIONS

MAGNIFICATION	$\times 5$
FIELD-OF-VIEW	$12^\circ$
MAX LEAD ANGLES	$21^\circ$
COMPUTER TARGET SPEED	up to 350 m/s
COMPUTER CROSSING RANGE	up to 1500 m for 40 mm gun
COMPUTER RANGE GROUND TARGETS	
20 mm gun	up to 2500 m
40 mm gun	up to 4000 m
HYDRAULIC SERVOS elevation	$-3.5$ to $+81.5^\circ$



azimuth	360°
MAX SPEED	
elevation	up to 55°/s
azimuth	up to 80°/s
MAX ACCELERATION	
elevation	75-120°/s <sup>2</sup>
azimuth	120-180°/s <sup>2</sup>
ENGINE POWER	7 hp
WEIGHT	250 kg

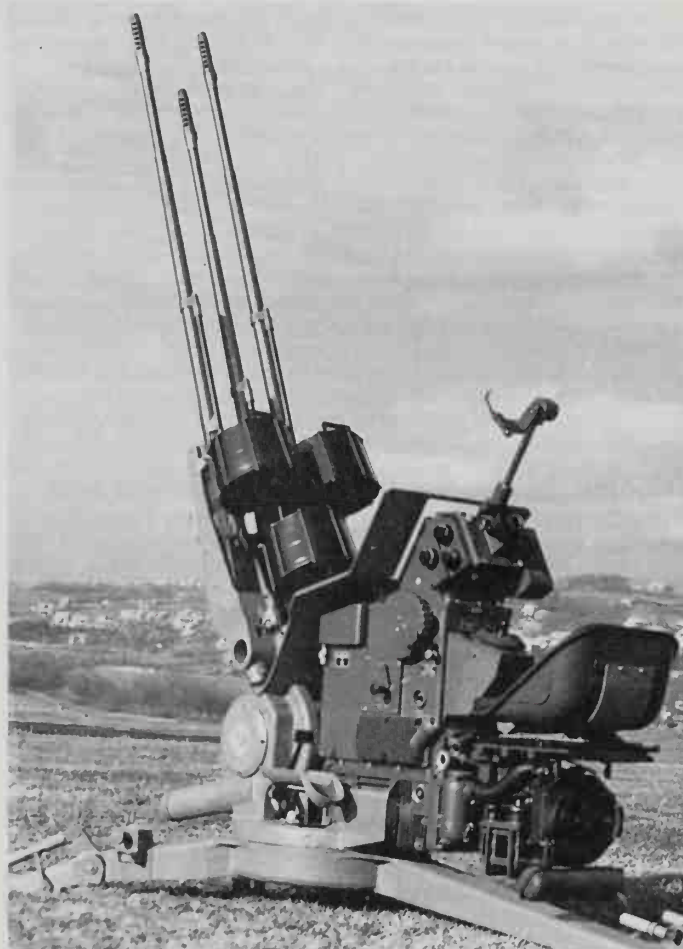
**Status:** Production as required. In service with many countries.

**Manufacturer:** Officine Galileo, Military Systems Division, Via A Einstein, I-35 - 50013 Campi Bisenzio, Florence, Italy.

Telephone: (055) 89501

Telex: 570126 GALILE I

Fax: (055) 8950600



*Yugoslav triple 20 mm anti-aircraft gun Type 20/3 M55 A4 B1 showing P56 sight, and engine mounted under gunner's seat*

## Officine Galileo Vanth Optical Sight and Fire Control System for Upgrading of Manual Anti-aircraft Guns

### Development

The Vanth optical sight and fire control system has been developed as a private venture by Officine Galileo between 1984 and 1985 with production commencing in 1988-89.

Vanth is a technically modernised P56 or P75 sight and can be fitted to a wide range of existing in-service towed light anti-aircraft gun systems such as the Chinese twin 37 mm system and the Bofors 40 mm L/60.

The Vanth is one of the three systems evaluated by Pakistan in 1989 on its Chinese-supplied twin 37 mm light anti-aircraft gun systems.

### Description

According to Officine Galileo older anti-aircraft guns, such as the Bofors 40 mm L/60 and the twin Chinese 37 mm systems, have, in their original configuration, a negligible hit probability against modern aircraft flying at speeds of over 150 m/s. Their manual operation is too slow and their accuracy is too poor due to their mechanical aiming system.

The anti-aircraft gun, when upgraded with Vanth, reaches the appropriate maximum speed, both in elevation and traverse, to allow accurate tracking of high speed aircraft and therefore increase their kill probability.

With the Vanth optical sight and fire control system the target is continuously tracked and aimed at in the centre of the optical telescope, while the weapon is automatically directed against the future point, according to the independent line-of-sight operating principle.

Gun aiming in elevation and bearing is controlled by means of two high performance electrohydraulic servo systems; lead angles in elevation and bearing are accurately given by a precision electronic computer.

For the operative point of view a battery of Vanth equipped guns is as effective as a battery of guns controlled by an external fire control system and far less expensive according to Officine Galileo. In addition it has the extra advantage of higher battery survivability because of the independence of each single weapon during aiming and firing, multiple threats can be faced at the same time and two people instead of four are required to operate each gun.



*Chinese twin 37 mm light anti-aircraft gun system deployed in firing position and fitted with Vanth sighting system*

The Vanth MA or MB systems can be used in the upgrading as required. In the case of the MA the target speed has to be estimated and introduced in the computer by the relevant control at the commencement of each firing mission.

The Vanth MB is the more sophisticated system and can be operated with no need of estimated speed due to the continuous measurements of the actual target range by means of the integrated laser rangefinder.

Both the Vanth MA and MB can be easily installed on the weapon as no modification is required to the weapon or its associated carriage.

Target acquisition can be made easier by designation in bearing from any available external source. The target, as soon as it is spotted, is aimed at by the open sight and subsequently tracked by the optical telescope.

The target is continuously observed before and during the firing because the weapon is largely independent of the line-of-sight. In an emergency hand wheels are provided to drive the gun manually.

**SPECIFICATIONS**

MAGNIFICATION	× 5
FIELD-OF-VIEW	12°
MAX LEAD ANGLES	21°
COMPUTER TARGET SPEED	
min	60 m/s
max	350 m/s
COMPUTER CROSSING RANGE	
min	100 m
max	1500 m
HYDRAULIC SERVOS	
elevation	-3.5 to +81.5°

azimuth	360°
MAX SPEED	
elevation	up to 55°/s
azimuth	up to 70°/s
MAX ACCELERATION	
traverse	95°/s²
elevation	80°/s²
WEIGHT	250 kg

**Status:** Production. In service with undisclosed countries.

**Manufacturer:** Officine Galileo, Military Systems Division, Via A Einstein, I-35 - 50013 Campi Bisenzio, Florence, Italy.  
Telephone: (055) 89501  
Telex: 570126 GALILE I  
Fax: (055) 8950600

## Officine Galileo Vanth/MB Optical Sight and Fire Control System for Anti-aircraft Guns

**Development**

In 1975 Officine Galileo started development of a new anti-aircraft sight called the P75, this was completed in 1977 and entered production the following year. Further development of this from 1986 resulted in the Vanth/MB, which was completed in 1987 with production commencing in 1988. By early 1991 over 80 units had been completed and production was continuing.

The Vanth/MB system has been designed for installation on towed anti-aircraft guns with calibres from 20 to 40 mm, including the Rheinmetall Rh 202 (twin 20 mm), Bofors 40 mm L/60 and L/70, Chinese single and twin 37 mm and the Breda Sentinel (twin 30 mm).

**Description**

The base model of the Vanth family consists of three main subassemblies; optical head, main structure and electrohydraulic servo system. This enables fully automatic computation to take place, based on laser ranging, local control with remote designation (radar or optical) and integrated autotest.

The optical head integrates the visual and laser (plus optional TV) channels into a single input/output optical path to ensure the necessary parallelism. The independent line-of-sight is an important advantage as it allows the operator to keep the target in the centre of the reticle at all times, while the gun leads automatically. The laser rangefinder incorporated is of the Nd:YAG type with high repetition and accuracy.

The main structure is located below the optical head and comprises a control joystick, manual manoeuvring and a microprocessor computer. The latter performs all the fire computations at high speed as well as taking into account the ballistic data when required. It controls and manages the operation of all the basic functions (optical sight, laser rangefinder and servos) as well as of the optional sensors and accessory functions (BITE, training and taboo arcs).

In addition, it permits the reconfiguration of system operation from the basic level, both upwards, by addition of optional modules and downwards, as a backup in case of partial failures. In the event of a laser failure, effective fire is still possible by using the estimated target speed.

The electrohydraulic servo system is mounted below the main structure and ensures very high performance in terms of speed, acceleration and aiming accuracy, which means very small dynamic error, even during firing.

Sight and gun control is done by the operator through a 2° of freedom joystick. In the backup mode, control is manual by means of hand wheels.

As the Vanth/MB is modular, it can be easily expanded to meet specific user requirements. Options include remote-control by an external fire control system, firing taboo arc setting, parallax and ballistic introduction, integrated training system, automatic TV tracking and a night operation capability using an infra-red module.



*Officine Galileo Vanth/MB sight from the front*

**Status:** In production. In service with undisclosed countries.

**Manufacturer:** Officine Galileo, Military Systems Division, Via A Einstein, I-35 - 50013 Campi Bisenzio, Florence, Italy.  
Telephone: (055) 89501  
Telex: 570126 GALILE I  
Fax: (055) 8950600



## SWEDEN

## Bofors Aerotronics UTAAS Fire Control System for Anti-aircraft Guns

## Development

The UTAAS fire control concept is a further development of well proven fire control systems produced by Bofors Aerotronics for the home and export markets. According to Bofors, the prime objective has been to increase cost-efficiency by maintaining a high degree of performance at reduced cost.

The first self-propelled application for this system is the 40 mm air defence version of the Combat Vehicle 90 family of vehicles being developed to meet the requirements of the Swedish Army. Full details of this vehicle armed with a 40 mm Bofors gun are given in the *Self-Propelled Anti-Aircraft Guns* section.

The sight can also be retrofitted to existing towed anti-aircraft guns such as the Bofors 40 mm L/60 and L/70 and the Chinese twin 37 mm systems. The UTAAS system was one of the three systems installed on Chinese-supplied twin 37 mm light anti-aircraft guns of the Pakistani Army for extensive trials held in mid-1989.



Bofors UTAAS fire control system installed on a towed anti-aircraft gun with sight on top and operator's console below

The UTAAS anti-aircraft version significantly increases hit probability and final intercept range is further extended when used to upgrade in-service weapons, such as Bofors 40 mm L/60 and L/70 weapons.

## Description

Like all Bofors Aerotronic systems, the UTAAS is based on the principle of an independent line-of-sight. This means that the gunner only has to control the line-of-sight. The gun is aimed-off with reference to the line-of-sight, the aiming mark remains steady on target while the gun moves to the correct superelevation and lead angles.

The main components of the UTAAS are the operator's panel, operator's handle and fire control computer.

The UTAAS sight itself is fitted with a top mirror which is servo-controlled from the fire control computer to accomplish the independent line-of-sight. The weapon is automatically laid with no re-aiming required.

The full ballistic solution is computed based on range to the target, speed and elevation, including compensation for meteorological conditions and barrel wear. During tracking, target range is repeatedly updated.

The UTAAS fire control system provides search radar interface, optical target designator interface and magnification, with field-of-view optimised for easy target detection and target acquisition, line-of-sight aiming and laser ranging via a servo-controlled mirror, automatic gun laying to aim-off direction, digital computation of the ballistic equations and track-while-fire capability.

The system has been designed for ease of operation and once it has entered into its target-acquisition mode, either by the gunner's designation of the target directly to the system or by using input from a radar or optronic sensor, the gunner only has to make minor corrections and start lasing. Lasing continues as the gun lays automatically. Indicators in the eyepiece tell the gunner when to open fire. Typical target engagement time is normally six seconds.

As UTAAS is a modular design, several options are available. These include video output from the sight, night capability by using thermal imaging or image intensification, stabilisation to compensate for ship or vehicle movement and alternative laser rangefinders.

A training facility forms an integral part of the fire control system software to provide the operator with a means to improve his tracking skill.

## SPECIFICATIONS

OPTICAL UNIT	
magnification	× 7
field-of-view	8°
MIRROR HEAD	
elevation	−10 to +60°
lead angle	20°
LASER UNIT	
type	Nd:YAG
repetition rate	5 pps
range	300-9995 m
UTAAS FIRE CONTROL COMPUTER	
range	300-9995 m (autofed input)
number of ammunition types	6 (manual input)
muzzle velocity, relative nominal	−120 to +70 m/s (manual/autofed input)
air temperature	−40 to +60°C (manual/autofed input)
air pressure	−30 to +10 kPa (manual/autofed input)
powder temperature	−40 to +60°C (manual/autofed input)
wind	0 to 30 m/s (manual/autofed input)

**Status:** Development complete. Ready for production.

**Manufacturer:** Bofors Aerotronics AB, S-181 81 Lidingo, Sweden.  
 Telephone: (46) 87316000  
 Telex: 19188 bofaero s  
 Fax: (46) 7659265

## Saab LVS-A Anti-aircraft Gun Sight

## Development

The LVS-A anti-aircraft gun sight has been developed as a private venture by Saab Instruments, part of the Combitech Group, to enable existing anti-aircraft guns to be upgraded at a low cost. Two versions have been developed; the LVS-A for installation on servo-controlled guns and the LVS-M for manually directed guns.

The main features of the Saab LVS-A can be summarised as follows; it measures the 3D target trajectory independently from gun movements, computes aim-off angles digitally, controls gun direction automatically and has a short reaction time. Little modification is required in order to fit the anti-aircraft sight system and little training required.

## Description

The LVS-A anti-aircraft gun sight comprises two main components; the target acquisition and tracking unit (TAU) and the system control unit (SCU).

The operator acquires and tracks the target using the TAU and during this phase all of the data required to determine the 3D target trajectory and velocity is collected.

During the coarse initial tracking phase, the gun is automatically slaved to the TAU sight line and in the final tracking phase, when the target is normally within range, the gun is automatically steered to computed aim-off angles relative to the actual sight line.

**Status:** Prototypes. By late 1990 a total of three systems had been completed. One LVS-A has been used for trials (together with the Swedish Defence Administration), one model LVS-A was retained by Saab Instruments while the third being a function model of the LVS-M which was being used by Saab Instruments for development work. The first prototype order was taken in late 1990.

**Manufacturer:** Saab Instruments AB, Box 1017, S-551 11, Jonköping, Sweden.

Telephone: (46) 36 19 41 00

Telex: 7005 saabjkg s

Fax: (46) 36 16 41 06



*Saab Instruments LVS-A anti-aircraft gun sight on Bofors 40 mm L/70 anti-aircraft gun photographed from the front*

## Weibull Anti-aircraft Sights

### Development

J L Weibull started development work on sight systems in 1970, although they had become involved in power-laying systems for various weapons well before this date. Today, the company manufactures two types of reflex sights; a small one with one graticule and a larger one with four different graticules. These sights can also form part of the company's upgrade packages for anti-aircraft guns such as the Bofors 40 mm L/60, which is fully covered in the *Towed Anti-Aircraft Guns* section.



*Weibull reflex sight attached to pintle-mounted 7.62 mm FN HERSTAL SA machine gun*



*J L Weibull reflex anti-aircraft sight*



According to the manufacturer, the Swedish Coastal Artillery has mounted J L Weibull sights on all of their anti-aircraft guns from the 7.62 mm machine gun up to the Bofors 40 mm (both L/60 and L/70). As these sights are similar, gunners can easily be transferred from one type of weapon to another with little additional training required. The Swedish Army also uses a J L Weibull reflex sight on the 20 mm turret fitted to its Pbv 302 armoured personnel carriers.

#### Description

#### Reflex Sight

This is equipped with four different graticules mounted on a revolving disc. Two are intended for air combat, one for fast moving targets and the other for slow moving targets. One is designed for sea target combat (and is also suitable for ground targets) and one graticule corresponds to the standard ring sight.

#### Centre-aimed Sight System

In the centre-aimed sight system, the Reflex sight (with cross-hairs graticule) is mounted onto a rotating table on a sight arm on the gun. The rotating table supports the sensors measuring the movement vertically and laterally. The sensors transmit the data to an onboard computer which also receives data from a rangefinder (radar or laser) mounted on the gun. As the gunner aims at the target, keeping it in the centre of the sight, the computer processes the sensor data and range data to calculate the required lead angle and drive the rotating table in both axes to the correct aim-off point. The gunner then places his cross-hairs (the centre of the sight) back over the target and fires.

**Status:** Production. In service with Sweden and other armed forces.

**Manufacturer:** J L Weibull AB, PO Box 43, S-232 02, Akarp, Sweden.

## SWITZERLAND

### Oerlikon-Contraves Gun King Sight

#### Development

The Gun King computerised multi-divergence laser sighting system was developed as a private venture by Oerlikon-Contraves for installation on a wide range of small- to medium-calibre air defence guns as well as self-propelled air defence systems. The Gun King can be installed on new weapons such as the Oerlikon-Contraves twin 35 mm GDF series weapons, or retrofitted to older weapons such as the Soviet ZU-23 and Chinese twin 37 mm systems. The Gun King was one of three sighting systems evaluated by Pakistan on its Chinese-supplied twin 37 mm anti-aircraft guns in 1989. By 1991 over 300 Gun King sights had been ordered.

#### Description

The Gun King sight has five key components: a periscope with a laser rangefinder as a tracking unit; a collimator for autonomous target acquisition; an operator's control unit; a sight electronics unit with a computer and the servo system and drives.

Once the target has been found by means of an external search radar or the collimator, the operator tracks it through the periscope. The integrated laser rangefinder measures the target distance continuously to provide three-dimensional information to the computer system.

There is a common optical path in the periscope for the laser beam and the operator's line-of-sight. Spectral beam splitting is effected by a system of lenses and prisms, specially coated to ensure operator safety. For engaging ground targets, the laser beam is narrowed to eliminate terrain clutter and for training purposes a TV camera may be mounted on a periscope. All information relating to meteorological parameters and muzzle velocity is entered into the computer via a keyboard and an alphanumeric display to compensate for its influence on the intercept calculation point. This enables the operator to concentrate on target tracking once the weapon is in position.

The gun and sight are operated by a control yoke which provides full hands-on control since all actuators are integrated in the yoke grips. The

Gun King allows computer-assisted tracking of the target and the operator only has to control the gun if the target manoeuvres.

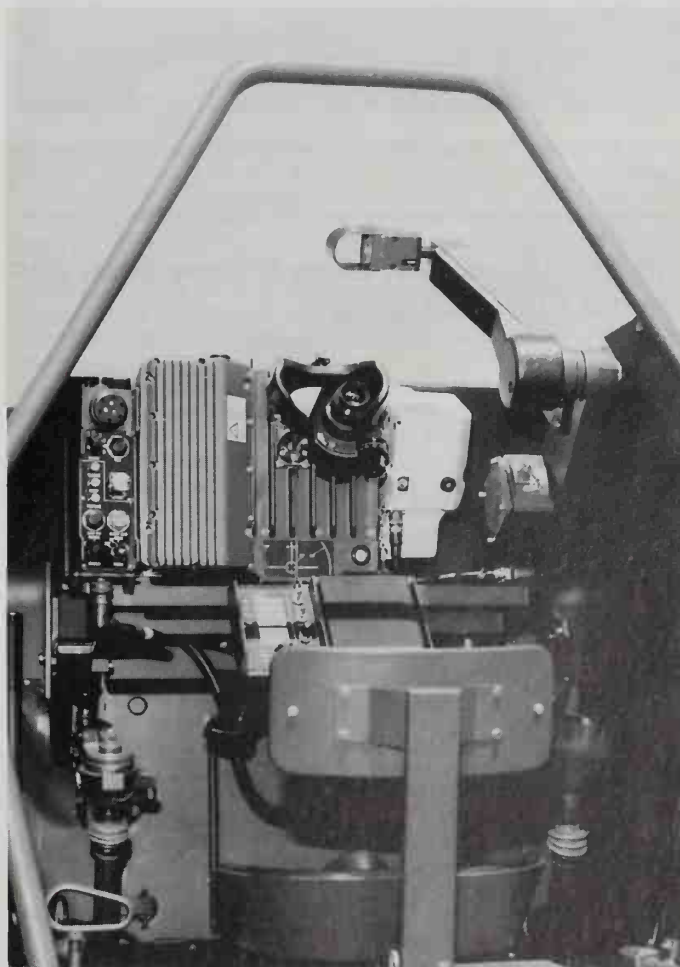
The high speed computer not only calculates all of the fire control data and ballistics, but also the gun drive electronics. At the moment of optimum hit probability, the operator receives an acoustic alarm to commence firing.

For control, modern DC power electronics and high performance DC servo drives are used. The DC power supply is fitted with buffer batteries to smooth out transient peak loads. The battery capacity ensures full operational readiness of the complete system and up to five combat cycles can be accomplished before the power supply engine has to be started to recharge the batteries.

Monitoring of the system function is effected on-line, even during the combat phase and a quick test enables functional checking of the system



Egyptian built ZU-23M ZU-23M twin 23 mm light anti-aircraft gun system fitted with Oerlikon-Contraves Gun King sight



Close up of Oerlikon-Contraves Gun King sight from rear installed on Oerlikon-Contraves GDF-005 twin 35 mm anti-aircraft gun

during start up. When a fault does occur, the faulty Line-Replacement Unit (LRU) is localised with the memory resident functional and diagnostic unit without external aids. The faulty LRU is then substituted in the field and returned to the rear for repair.

**Status:** In production. In service with a number of countries including Canada, Cyprus and Saudi Arabia.

**Manufacturer:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.  
Telephone: (01) 306 22 11  
Telex: 823 402 coz ch  
Fax: (01) 301 34 66

## UNITED KINGDOM

### BMARC SLC-001 Lead Computing Sight

#### Development/Description

The SLC-001 lead computing sight has been developed as a private venture by the British Manufacture and Research Company it was announced for the first time in 1989 and entered low-rate initial production in 1991.

The SLC-001 is a lightweight, self-contained, low-cost gunsight for use against fast moving aerial or ground targets and it automatically calculates the required lead angle by a new patented method.



*British Manufacture and Research Company SLC-001 lead computing sight installed on top of a naval weapon*

A cross line graticule is projected to infinity, generated by a cathode ray tube and controlled by gyros while the aimer simply tracks the target and opens fire at the correct range.

It can be installed on all land-based and naval guns from 12.7 mm to 40 mm calibre, including non-powered guns.

It can be fitted to new production anti-aircraft guns or retrofitted to older guns using its own self-contained readily changed battery pack or using an available on-mounting supply at the request of the customer.

The sight is easily fitted to existing weapons as it has a dovetail fitting aligned to the cannon boresight. The fitting slides into a universal alignment bracket and is clamped by two thumb screws.

As an option a video output can be provided for training purposes.

#### SPECIFICATIONS

WEIGHT COMPLETE	3 kg
LENGTH OVERALL	360 mm
WIDTH OVERALL	175 mm
HEIGHT OVERALL	130 mm (above alignment bracket)
FIELD-OF-VIEW	50° × 17°
APERTURE	100 mm × 35 mm
FOCAL LENGTH	100 mm
OPERATING VOLTAGE	
battery	10 × Ni/Cd cells
MOUNTING SUPPLY	DC as specified by customer

**Status:** Development complete. Entering production.

**Manufacturer:** British Manufacture and Research Company, Springfield Road, Grantham, Lincolnshire NG31 7JB, UK.  
Telephone: (0476) 65577  
Telex: 37635  
Fax: (0476) 65614

### British Aerospace (Systems & Equipment) Air Defence Gun Sight

#### Development

The Air Defence Gun Sight has been developed as a private venture by British Aerospace (Systems & Equipment) and was shown for the first time in 1988. It has been designed as a low-cost computer-controlled gun sight which can be easily fitted to existing weapons in the 20 mm to 57 mm range, for example the Bofors 40 mm L/70 used by many countries around the world.

The sight is capable of being operated by one man and can be fitted with minor modifications to most servo-assisted and manually operated ground or naval guns that use a single layer.

The sight is designed for engagements against crossing or head-on attacking aircraft at speeds of up to 300 m/s at ranges out to 4000 m.

#### Description

The fire control system consists of the following major components; laser rangefinder/sight, sight platform, electronic unit, control and display unit, operator controls and training simulator.

The laser rangefinder/sight serves three functions; ranging the target, providing the aiming mark and quality optics and magnification for smoother tracking.

The rangefinder is a modified hand-held monocular unit which is of modular design, making it possible to use a thermal imager/rangefinder combination for 24 hour clear weather operation.

The rangefinder is mounted on the sight platform at a comfortable position for the layer. In the case of the Bofors 40 mm L/70 weapon the sight platform is attached to a modified sight arm which replaces the existing sight arm and sight.

The platform contains a two axis rate-gyro, two angle pick-offs, a vertical sensor, two gearboxes and their associated servo motors. The rate-gyro is



*Bofors 40 mm L/70 anti-aircraft gun fitted with British Aerospace (Systems & Equipment) Air Defence Gun Sight on left side of mount*

mounted with its spin axis parallel to the laser axis and provides the computer with target angular rates. The gyro is also used to maintain a measure of elevation and bearing of the barrel for wind drift and gravity drop compensation.



The electro unit contains the power supplies, servo electronics, microprocessor and signal processing electronics.

The control and display unit is small and is used for mode selection, data entry and calibration and allows for the following major items of data to be inserted: ammunition type, air temperature, barometric pressure, wind direction, wind speed, humidity and variations in muzzle velocity.

The simulator injects the image of a target into the sight. Sight superelevation and aim-off are generated to give a realistic engagement sequence. A more sophisticated digital simulator is available if required.

A typical target engagement sequence is as follows:

- (1) target is detected
- (2) layer lays the gun using a wide angle mechanical sight mounted on the laser rangefinder/sight
- (3) layer tracks the target through the rangefinder/sight and identifies aircraft as hostile
- (4) layer fires the laser rangefinder and range data is obtained
- (5) aim-off is automatically applied to the gun barrel and when applied is confirmed to the layer by a light indication

(6) a flashing light in the sight indicates to the layer that the target is in range

(7) layer fires the gun.

The accuracy of the total weapon system is a function of ballistic dispersion, performance of the layer and the inherent accuracy of the sight. The accuracy of the sight alone, against an aircraft at a range of 4000 m is such that 95 per cent of the rounds will fall within 2 mils of the desired point of impact.

Engagement time against an aircraft flying at a range of 4000 m will be approximately four seconds (that is, from the time the laser fire button is first pressed to the time when the aim-off applied indicator is lit).

**Status:** Prototype. Ready for final development and production.

**Manufacturer:** British Aerospace (Systems & Equipment) Limited, Clifton Road, Southway, Plymouth, Devon PL6 6DE, UK.

Telephone: (0752) 695695

## GEC Ferranti GSA Series Anti-aircraft Sights

### Development

The GSA Series of anti-aircraft sights were developed by the Sighting Systems Group of GEC Ferranti from the original Gyro Gun Sights which Ferranti started manufacturing for fighter aircraft in 1943. They have been designed to provide a lead computing, optical tracking facility for medium calibre guns, and by early 1991 several thousand had been built for a wide range of weapons including the Oerlikon-Contrares GDF and GCM series of twin 35 mm systems and the Bofors 40 mm L/70.

The existing GSA 200 and 300 series has recently been augmented by the GSA 400 which is compatible with the earlier models. All three models require only 24 V DC power supply, can be used with the Ferranti TA 500 Training Aid and all use the same Test Equipment.

### Description

#### GSA 200 Series and 300 Series

The GSA 200 Series and 300 Series sights are similar in construction and use. They both utilise the well proven GEC Ferranti two axis rate gyroscope to measure the target movement and generate the appropriate lead angle for the aiming graticule. A fixed graticule is also provided for surface-to-surface targets and provision is made for an auxiliary telescope to aid target identification. Various graticule patterns can be supplied to suit particular requirements.

The sights are contained in a robust, watertight housing and are suitable for both land and naval use. Standard mountings are available to suit Bofors and Oerlikon sight mounts and others can be manufactured to customer requirements. Visors can be supplied as accessories.

The GSA 200 Series has two preset ranges and a facility to cage the gyroscope during target acquisition. The GSA 300 Series has three preset ranges and a facility to cage the gyroscope during target acquisition.

#### GSA 400 Series

The GSA 400 Series incorporates a newly designed version of the two axis rate gyroscope which has the facility to measure the position of the gyroscope axis at any time. This enables a microprocessor to control the response of the Gyroscope to compensate for gyroscope frictional dip, sensitivity and optical non-linearities. This substantially improves the accuracy of the sight at large deflection angles and permits maximum preset range settings of up to 3 km. Topping of the gyro at its deflection limits is also prevented.

The GSA 400 Series can be programmed for any type of ammunition without factory calibration, and the four range settings can be altered as required without special test facilities. At switch-on the microprocessor carries out a full system check and confirms that the sight is fully functional. Graticule illumination is by high intensity LED, ensuring high visibility against bright backgrounds and spectral compatibility with Night Vision Goggles. Graticule illumination is fully adjustable to suit ambient light conditions.



Oerlikon-Contrares GDF series twin 35 mm towed anti-aircraft gun system showing GEC Ferranti GSA 300 Series sight on right



The GSA 400 front panel contains preset selector switches for gyro/fixed reticles, fast/slow targets, two types of ammunition, four preset target ranges and dimmer control. In addition there are controls for entering data into the computer and performing built-in test

Growth options include external inputs of suitable laser or radar range and an output of sightline position information is available.

The GSA 400 Series is compatible with existing GSA sight mounts and is suitable either as a replacement for earlier sights, or for new applications where its high intrinsic accuracy can be fully exploited.

#### SPECIFICATIONS

LENGTH	250 mm
WIDTH	160 mm
HEIGHT	250 mm
WEIGHT	7.8 kg

**Status:** In production. In service with over 20 countries.

**Manufacturer:** GEC Ferranti Defence Systems Limited, Display Systems Division, 1 South Gyle Crescent, Edinburgh EH12 9HQ, Scotland.  
Telephone: (031) 316 4545  
Telex: 727101  
Fax: (031) 314 8237

## BMARC RC35 Air Defence Sight

#### Development

The RC35 air defence sight was designed by Ring Sights for installation on light anti-aircraft guns ranging in calibre from 20 mm up to 40 mm with production being undertaken by the British Manufacture and Research Company.

#### Description

The RC35 is a reflex collimator self-illuminated sight with no magnification and is designed to provide surveillance, acquisition, target assessment and aiming.

As the sight is used with both eyes open the gunner can search for targets by moving his head rather than the weapon itself. He can then bring the gun to bear without losing sight of the target. As the weapon is aligned the sight graticule comes into view.

The graticule, which is boresighted to the gun, is projected to infinity and is always in focus. The standard graticule is for use by 20 mm to 40 mm guns in low level air defence and against surface targets. Alternative graticules for other calibres and applications are available. On the left side of the RC35 is an emergency sight, and for low light operation a gaseous light source having an effective life of six years is fitted as standard.

#### SPECIFICATIONS

FIELD-OF-VIEW	18° × 12°
APERTURE	35 mm × 35 mm
FOCAL LENGTH	157 mm
LENGTH	240 mm
WEIGHT	0.9 kg
EYE POSITION	50-100 mm behind sight



*RC35 air defence sight*

**Status:** In production. In service with Royal Navy and other undisclosed countries.

**Manufacturers:** British Manufacture and Research Company Limited, Springfield Road, Grantham, Lincolnshire NG31 7JB, UK.  
Telephone: (0476) 65577  
Telex: 37635  
Fax: (0476) 65614

## Hall and Watts RC25 All Arms Air Defence and Ground Role Sight

#### Development

This sight was originally developed as a private venture by Ring Sights, but was subsequently taken over by Hall and Watts who are now totally responsible for both manufacture and marketing. The first prototype of the RC25 All Arms Air Defence Sight was completed in 1985 with first production for export in 1987. In 1989, it was adopted as the Sight Unit L14A1 by the British Army for its All Arms Air Defence (AAAD) System.

This system comprises the RC25 sight, a 12.7 mm MG, a softmount and vehicle interface.

A total of 1050 AAAD systems are being procured for the British Royal Artillery and fitted to a number of in-service vehicles including the FV432 APC, FV436 command post vehicle, 155 mm M109A2 self-propelled howitzer, VSEL 155 mm AS90 self-propelled gun and the Tracked Rapier Support Vehicle.

The RC25 has since been taken into service by other UK MoD users on the 7.62 mm GPMG. It is also in service with other NATO nations and many countries worldwide on both 12.7 mm and 7.62 mm weapon systems. The sight saw service in the 1991 Gulf War.

#### Description

The RC25 is a reflect collimator sight of unity magnification with the graticule focused on infinity. In use, the operator's eyes are positioned approximately 150 mm from the sight, which allows room for a respirator to be worn. Since the sight has no magnification and is used with both eyes open, there is no eye strain and a wide field-of-view is available. This is particularly useful in the air defence role, allowing entire flight paths of approaching aircraft to be seen and the target quickly acquired. The sight



*Hall and Watts RC25 all arms air defence and ground role sight installed on a 12.7 mm M2 machine gun*

provides specific aiming points for fighters or combat helicopters approaching at different speeds and angles.

The RC25 is rugged, sealed and virtually maintenance free and can be retrofitted to all types of pintle-mounted machine guns. Sight-to-weapon interfaces can be designed to customer requirements.

The RC25 is produced with a variety of graticule patterns designed to address both the ballistic characteristics of the weapon and the user requirements in the ground-to-air, ground-to-ground and air-to-air role.



**SPECIFICATIONS**

FIELD-OF-VIEW	14.25° × 14.25° (250 × 250 mils)
MAGNIFICATION	× 1
APERTURE	25 mm × 25 mm
FOCAL LENGTH	122 mm
LENGTH	190 mm
TEMPERATURE RANGE	-40 to +55°C

**Status:** In production. In service with the British forces and many other undisclosed countries.

**Manufacturer:** Hall and Watts Defence Optics Limited, 266 Hatfield Road, St Albans, Hertfordshire, AL1 4UN, UK.  
Telephone: (0727) 859288  
Telex: 267001 Watts G  
Fax: (0727) 835683

## Ring Sights Worldwide LC-40-100 Anti-aircraft Sight

**Development**

The LC-40-100 was designed by Ring Sights Limited with production and marketing being undertaken by Ring Sights Worldwide and 'like all of their sights' prismatically projects a graticule pattern into the vision field and does not require the eye to be centered in the unit.

It was originally developed to meet the requirements of British Aerospace as a backup sight for their private venture Air Defence Gun Sight (ADGS) (qv) which has been trialled on a Bofors 40 mm L/70 anti-aircraft gun.

The prototype LC-40-100 was completed in 1989 and trials have been carried out in some 12 countries on a wide range of weapons in both land and sea applications. An initial batch production of 1500 sights got underway late in 1989 with first deliveries in the Spring of 1990.

**Description**

Two versions are available, one for mounting on the standard 12.7 mm (50 cal) M2 Browning machine gun and the other for installation on cannon with calibres of 20 mm and up to 40 mm.

It has both land and sea applications and can be used to engage both stationary and moving targets giving an increased hit probability.

In the designation, LC stands for Linear Collimator, 40 is the aperture diameter in millimetres and 100 is the length in millimetres.

The cannon version has a standard NATO mount and fits straight onto the standard naval zeroing mount while the machine gun version has an integral zeroing mechanism on the standard NATO dovetail which can be quickly attached to most 12.7 mm (50 cal) machine guns using the optional NATO mount.

The LC-40-100 sight incorporates a solid glass unit power optic with a graticule focussed on the target. As it is solid glass there are no seals to leak, no internal misting up or moisture to obscure the view and neither dust nor sand can penetrate the sight and cause damage or inaccuracies.

The LC-40-100 replaces the traditional cartwheel sight which needed the eye, the corn and the chosen spot on the cartwheel and the targets all to be in line. Using the Ring Sight only the target has to be laid on the chosen spot on the graticule.

It has a large aperture of 40 mm that allows the user greater visibility and quick acquisition of targets with the graticule giving tangent elevation and lead stadia.

Both versions of the LC-40-100 have an anti-aircraft graticule and a flip-up Tritium light source.

Different graticules, light sources and zeroing attachments can be provided. In addition aim readout and moving spot gyro options will soon be available to meet specific user requirements.

**SPECIFICATIONS**

APERTURE	40 mm	40 mm
LENGTH	170 mm (MG)	120 mm (cannon)
WIDTH	65 mm (MG)	55 mm (cannon)
HEIGHT	120 mm (MG)	90 mm (cannon)
WEIGHT	1.7 kg (MG)	1.1 kg (cannon)
ZEROABLE	yes (MG)	optional (cannon)

**Status:** In production.

**Manufacturer:** Ring Sights Worldwide Limited, PO Box 22, Bordon, Hampshire GU35 9PD, UK.  
Telephone: (0420) 472295  
Telex: 859535  
Fax: (0420) 478359



Ring Sights Worldwide LC-40-100 anti-aircraft gun sight from gunner's side

## YUGOSLAVIA

**Rudi Čajavec Computerised Fire Control System for Light Anti-aircraft Guns****Development/Description**

Rudi Čajavec Defence Electronics of Yugoslavia has developed to the prototype stage a computerised fire control system that can be fitted to light anti-aircraft guns of 20, 23, 30, 35 and 40 mm calibres to improve their hit probability when engaging both ground and aerial targets.

For trials purposes it has already been installed on a Czechoslovakian twin 30 mm M53/59 self-propelled anti-aircraft gun system of the Yugoslav Army.

Main components of the system include a central computer which receives and issues information from a number of subsystems including the gunner's optical sight which also includes a laser rangefinder, computer control panel, gunner's controls, target data receiver and gun drive and position sensors. Additional components include a signal distribution box and two electric power distribution boxes.

If required the target data receiver can also receive information from an optical target indicator and a search acquisition radar.

The modular design of the system is such that it can be easily refitted to existing guns and can be tailor-made to meet specific operational and user requirements.

The man/machine interface of the computerised fire control system has been specifically designed for ease of operation.

**SPECIFICATIONS****OPTICAL SIGHT**

20° wide field-of-view, 7° narrow field-of-view, magnification  $\times 3.5$ ,  $\times 5$  and  $\times 10$ , night channel, passive second-generation or thermal channel, laser protection filter, independent line-of-sight, two-axis deviator

**LASER RANGEFINDER****COMPUTER****COMPUTER INPUTS****COMPUTER OUTPUTS**

Nd:YAG, maximum range 10 000 m  
16-bit, two ballistics  
target distance, meteorological data and parallax data  
lead angle, angular tracking and ballistic corrections

**Status:** Development complete. Ready for production on receipt of orders.

**Manufacturer:** Rudi Čajavec Defence Electronics, Yu-78000 Banja Luka, Braće Pavlića 23A, Yugoslavia.

Telephone: (078) 46-707

Fax: 33482

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# Static and Towed Surface-to-Air Missile Systems

(Including tactical anti-ballistic missile systems currently under development)

## BRAZIL

### AVIBRAS Solar Low Altitude Surface-to-air Missile System

#### Development/Description

The Brazilian company AVIBRAS Industria Aerospacial SA is at the prototype stage for a four-round mobile/static missile system known as Solar by the Brazilian Army. Similar in many respects to the Euromissile Roland, the weapon is likely to be integrated with the company's EDT-FILA anti-aircraft fire control system which is used with the army's Bofors 40 mm L/70 air defence guns.

**Status:** Recent information has indicated that owing to the current Brazilian economic position this project has been halted.

**Manufacturer:** AVIBRAS INDUSTRIA AEROSPACIAL SA, Marketing Division, Rodovia dos Tamdiós, KM14-PO Box 278 12300 Jacaref, São Paulo, Brazil.

Telephone: (55-123) 51 6637

Telex: (123) 3493 AIAE BR

Fax: (55-123) 516048/516706

## CHINA, PEOPLE'S REPUBLIC

### CPMIEC FM-80 Low Altitude Surface-to-air Missile System

#### Development

At the 1989 Dubai Aerospace Show the CPMIEC FM-80 all-weather low and very low altitude surface-to-air missile system was revealed for the first time. The system was developed over the period 1978 to 1988 and is designed as a shelter- or vehicle-mounted air defence system for close-in use around airfields, army field units and other Vital Point (VP) and communications hub installations. Its official designation is believed to be HQ-7.

The development of the FM-80 appears to have been aided considerably by a technology transfer package from France involving the Thomson-CSF Crotale SAM system. The resultant FM-80 system is very similar in physical and technical characteristics to the Shelter version of Crotale.

A typical shelter-mounted Operational Wing comprises three Operational Sections (batteries) and a Technical Support Section, with both direct support (some 10 vehicles comprising an electronic maintenance vehicle, mechanical maintenance vehicle, electronic spare shelter, collimation mast trailer, missile testing vehicle, missile launcher testing vehicle, a mobile 12 kW generator vehicle, a missile transporter-loader vehicle, a missile transporting vehicle and a 40 kW generator vehicle) and indirect support (with various special test benches and standard test equipment) maintenance groups.



Missile being launched from top right canister with top of tracking radar between two launchers

Each battery comprises a Search Unit (SS), three Firing Units (FS), three optical aiming systems and four 40 kW generators.

#### Description (shelter-mounted version)

The Operational Section has a multi-target interception capability as follows:

- (a) the three firing units can simultaneously deal with targets either coming from one direction or from different directions
- (b) a single firing unit can engage targets from the same approaching group four times
- (c) a single firing unit can engage a single target from four different target groups attacking from four different directions.

With the components comprising the system it can operate in one of three missile guidance operating modes. The exact mode is chosen by the operator to fit the operational scenario. The modes are:

- (a) IR - radar, where the target is tracked by the radar, the missile is launched and gathered by the IR localiser and the radar is used to track and measure the missile's angular deviation so as to generate the command radio guidance system signals to guide the weapon to the intercept point
- (b) TV - IR - radar, where the target is tracked by the passive TV system, the missile is launched and gathered by the IR localiser and its range and angular deviation determined by the radar. The command radio guidance system then generates the control orders to guide it to the target intercept point
- (c) Manual Operation, used where the tracking radar's target channel is subjected to jamming so the operator tracks the target using the handgrip of the TV tracker. The range and angular deviation of the target is measured by the radar and the missile is guided by the command radio guidance system.

The shelter-mounted FM-80 search unit is used to search, identify, evaluate and classify the targets. It then designates the most dangerous targets and distributes the information to the allocated firing unit(s). If its radar is jammed then the optical aiming units of the firing units can be used to acquire and designate targets.

The Search Unit comprises the following subsystems:

- (a) a 4.15 m long, 1.33 m high and 2.6 m wide trailer-mounted shelter unit, that weighs 8700 kg when fully loaded, and towing vehicle
- (b) an E/F-band 60 rpm pulse Doppler search radar which has an operational range of 3200-19 200 m, a beamwidth in elevation (single beam) of 0-27° (or switchable in 0-7°) and in azimuth of 3.6°. Target designation accuracy is 80 m in range and 7 mrad in azimuth
- (c) a data processing unit which is able to process 30 targets and in conjunction with the radar system track 12 simultaneously, classify the incoming targets, evaluate the threat aspect and then allocate the three most dangerous targets to the designated firing unit(s)
- (d) a wire or radio data link network between itself and the firing units
- (e) an IFF system
- (f) a radio station.



*Shelter-mounted surveillance radar used with FM-80 surface-to-air missile system*

As already stated, if the search unit is subjected to hostile jamming or fails to work because of other reasons the firing unit's optical aiming device can be used to visually track the target and send data to the firing unit. This device has a  $7^\circ$  field-of-view and a maximum operational range (in fair visibility) of more than 12 000 m.

The firing unit function is to receive the target designation data (from either the search unit or the optical aiming device) so as to enable the tracking radar to search in elevation. When the radar or passive TV tracking system acquires the target and goes to automatic tracking, the firing unit computes the firing solution. Once the engagement parameters are met, the designated missile is fired and the IR localiser determines the weapon's angular deviation and it is gathered through the radio remote-control commands.

Once the missile has entered into the main radar beam, the IR localiser hands over the guidance to the radar. Then the radar measures the relative angular deviation of the missile from the target, and flight control commands are generated to guide the missile to the intercept point with the target. If the firing unit radar is jammed then an alternative guidance mode is chosen.

The firing unit comprises the following subsystems:

- a 4.15 m long, 1.33 m high, 2.6 m wide trailer-mounted shelter unit, which weighs 11 000 kg when fully loaded, and a towing vehicle
- a monopulse J-band tracking radar with an operational range of up to 18 000 m, rotational limits in azimuth of  $360^\circ$  and in elevation of  $-5$  to  $+70^\circ$  and relative accuracy of 0.1 mrad. The missile control transmitter operates in the I/J-bands using a  $10^\circ$  antenna beamwidth and an operational range of 12 000 m plus
- a TV tracking system with an operational range in fair weather of better than 15 000 m, a  $3^\circ$  field-of-view and a tracking accuracy of 0.3 mrad
- an infra-red (IR) localiser with a  $10 \times 10^\circ$  wide field-of-view and  $4 \times 5^\circ$  narrow field-of-view
- a data processing unit
- a wire or radio data link network between itself, the search unit and other firing units
- a four-tube launcher, turret and missile sequencer assembly. The missiles can be launched either singly or in a ripple mode with three seconds between firings.

The 40 kW trailer-mounted generators are individually used to supply power to the search and firing units.

The FM-80 missile is 3 m long and weighs 84.5 kg at launch. It is contained in a sealed cylindrical container which also acts as the launch tube. Propulsion is by a single stage solid propellant rocket motor that gives the weapon a maximum speed of 750 m/s. Flight control is by cruciform canard fins. The warhead is of the focused HE-fragmentation type and is fitted with a passive proximity fuzing system. Its lethal radius is 8 m. Minimum operational range is 500 m and maximum operational range is 8600 m against a 400 m/s target, 10 000 m against a 300 m/s target and approximately 12 000 m against helicopters. Operational altitude limits are from 15 to 5500 m.

The Single Shot Kill Probability of a single round is 0.85 to 0.90 whilst for two rounds against the same target it is greater than 0.96.

**Status:** Production. In service with People's Republic of China Armed Forces.

**Manufacturer:** Chinese state factories.

Enquiries to: Chinese Precision Machinery Import and Export Corporation (CPMIEC), 17 Wenchang Hutong Xidan, Beijing, People's Republic of China.

Telephone: 895012/831 1804

Telex: 22484 CPMC CN

## CPMIEC KS-1 Low to High Altitude Surface-to-air Missile System

### Development/Description

During 1991 the CPMIEC revealed that it was developing a new SAM system for the Chinese Armed Forces, the KS-1, with a striking physical similarity to the British Aerospace Dynamics Rapier. Available information indicates it is a command guidance weapon that is capable of high manoeuvrability. A phased-array acquisition and tracking radar is known to be part of the system.

Missile length is 5.6 m, diameter 0.4 m and launch weight 900 kg. Engagement altitude limits are said to be from 500 to 25 000 m, with a solid

propellant rocket motor propulsion system giving the missile an effective range of between 7000 to 25 000 m.

**Status:** Development.

**Manufacturer:** Chinese state factories.

Enquiries to: Chinese Precision Machinery Import and Export Corporation (CPMIEC), 17 Wenchang Hutong Xidan, Beijing, People's Republic of China.

Telephone: 895012/831 1804

Telex: 22484 CPMC CN

## CPMIEC RF-61A Low to Medium Altitude Surface-to-air Missile System

### Development

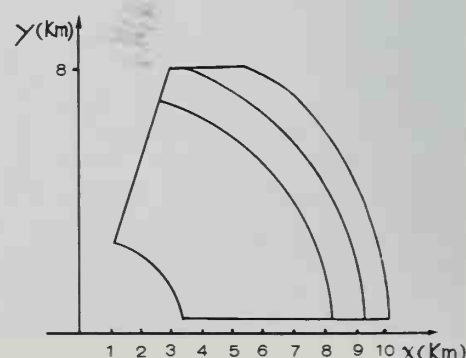
The RF-61A SAM system has been designed to meet the requirements of both the Chinese People's Liberation Army and Navy and in many respects the missile is similar to the US Sparrow family design but is larger and heavier. The two versions are the RF-61 for the Navy and the RF-61A for the Army.

The army version was first seen in public during the November 1986 Beijing defence exhibition, by which time it had been under development for some years to meet a projected service date in the late 1980s.

The system has been designed to engage targets flying at low to medium altitudes with a minimum range of 2.5 km and a maximum range of 12.5 km in the horizontal plane, extending in an arc to an altitude of around 10 000 m.

### Description

This missile itself is single stage with a solid propellant rocket motor, a chain type high explosive warhead, dual fuze system, homing head using a continuous wave semi-active homing guidance system which is said to



*Typical target envelope of RF-61A SAM system in vertical plane*





RF-61A SAM system with stabilisers lowered and launcher traversed to left



RF-61A missile being launched during trials in 1986

have an anti-jamming feature, autopilot, airborne power supply using a combustion turbine generator to supply AC and DC power for all missile components and four hydraulic servo-operated canard fins.

A typical army battery of RF-61A launchers consists of four 6 × 6 trucks each with two rail-mounted missiles on a turntable at the rear of the vehicle, mobile generators, command post vehicle, tracking and illuminating radar vehicle and a target indicating radar vehicle. The latter is also based on a 6 × 6 chassis which is similar in appearance to the Soviet-designed Flat Face target acquisition radar used with the Soviet SA-3 'Goa' SAM system.

The launcher vehicle has a fully enclosed forward control cab with an anti-blast shield to its immediate rear. When in the firing position the launcher is supported on four stabilisers, two each side. Reload missiles are brought up by a missile resupply truck and loaded with the aid of a crane.



CNEIEC Model 571 C-band radar deployed in field showing two elliptic parabolic net reflectors one above the other. A similar vehicle carries the generator

A typical target engagement would take place as follows. The target is first detected by the target indication and radar vehicle and after being confirmed as hostile, is tracked and illuminated by the tracking and illuminating radar vehicle. When the target is within range a missile is launched. It appears that the system can engage only one target at a time.

No details of the tracking and illuminating radar system have been disclosed, although the single photograph released shows a dish-type antenna with a TV camera mounted coaxially to the right for use in an ECM environment, or passive operations during clear weather engagements.

The target indication and radar vehicle is based on a different (6 × 6) 2500 kg cross-country truck model, as is the power supply truck.

The C-band radar system has the Chinese designation Model 571 and has two elliptic parabolic net type reflectors. The speed of rotation is 3 or 6 rpm. Other features include moving target indication and frequency-hopping agility. According to the Chinese, the Model 571 radar has been designed specifically for low altitude warning and displays both the slant range and azimuth of aircraft targets detected.

#### SPECIFICATIONS (missile)

TYPE	single stage low to medium altitude
LENGTH	3.99 m
DIAMETER	0.286 m
MAX SPAN	0.997 m
LAUNCH WEIGHT	320 kg
PROPULSION	solid fuel sustainer
GUIDANCE	command with semi-active radar terminal homing
WARHEAD	HE fragmentation
MAX SPEED	Mach 3.0
MAX RANGE	12 000 m
MIN RANGE	2500 m
MAX ALTITUDE	10 000 m
LAUNCHER TYPE	mobile twin rail

**Status:** In production. In service with the Chinese Army.

**Manufacturer:** Chinese state factories.

Export marketing carried out by Chinese Precision Machinery Import and Export Corporation, 17 Wenchang Hutong Xidan, Beijing, People's Republic of China.

Telephone: 895012/831 1804

Telex: 22484 CPMC CN

The Model 571 radar is marketed by China National Electronics Import & Export Corporation, 49 Fuxing Road, Beijing, People's Republic of China.

Telephone: 810910

Telex: 22475 CEIEC CN

## CPMIEC HQ-1 Medium to High Altitude Surface-to-air Missile System

### Development/Description

The HQ-1 (Hong Qian meaning Red Flag-1; US designation CSA-1) surface-to-air missile was a licence-produced version of the Soviet supplied SA-2a/b 'Guideline' SAMs used by the Chinese People's Liberation Army Air Force.

The first transfer of information technology occurred in March 1959 with actual production of parts starting in March 1961. In July 1963 the first flight test took place and by the end of that year limited production of operational rounds was underway. The final weapon acceptance tests were conducted between May and October 1964. In December of that year the HQ-1 was certified for full-scale production.

Both the Soviet supplied SA-2 and the locally built HQ-1 saw combat service on a number of occasions in the early to mid-1960s over mainland China against high altitude Taiwanese flown Lockheed U-2 reconnaissance aircraft. The missiles claimed four U-2s one in each of the years 1962, 1963, 1964 and 1965.

Partly as a result of these overflights, design work was begun during 1964 to upgrade the HQ-1 design to improve its range and engagement envelope. Designated the HQ-2 (qv) the modified missile passed its firing trials in June 1965.

Production of the HQ-1 is believed to have been completed in the late 1960s.

**Status:** Production complete. In service with the Chinese Armed Forces. It is probable that the HQ-1 system has been replaced in most front line units by the improved HQ-2 SAM system covered in the following entry.

## CPMIEC HQ-2 Low to High Altitude Surface-to-air Missile System

### Development

The HQ-2 missile system is a redesign of the HQ-1 medium to high altitude SAM (a licence-built variant of the Soviet SA-2a/b 'Guideline'). The design was begun in 1964 to improve the HQ-1's range and operational engagement envelope against targets such as the high flying U-2 reconnaissance aircraft seen over strategic areas of mainland China.

The HQ-2 passed its firing trial certification in June 1965 and entered production on a moderate scale soon after. Export marketing of the missile itself and the technology involved has been carried out by the China Precision Machinery Import and Export Corporation.

The HQ-2 has seen combat service with the Chinese People's Liberation Army Air Force in the late sixties against the Taiwanese flown U-2s; the missiles claimed five U-2s, one in each of the years 1967, 1968 and 1970 and two in 1969.

It has also been used in the Gulf War by Iran during the period 1985-89 and against US Air Force SR-71 reconnaissance aircraft by North Korea. The latter country has also imported HQ-2 technology from China in order to maintain its own stocks of the weapon and Soviet supplied SA-2s.

Over the 25 years of HQ-2 production a series of variants have been produced to form a complete family; these are the HQ-2B, HQ-2F, HQ-2J and HQ-2P. The missiles have been matched by improvements to the missile guidance radars. The HQ-2 family members also have a secondary ground and anti-shipping surface-to-surface attack capability.

### Description (HQ-2J model)

The HQ-2J launcher battalion comprises the following: a launching installation with a fire control vehicle and six semi-fixed trainable single-rail launchers (with 360° traverse and elevation limits of +11 to +65°); 24 missiles (six on the launcher rails and the rest either at the battalion reload storage facility in canisters or carried ready for loading on the transloader vehicles); six transloader vehicles with semi-trailers carrying single ready to load missiles and associated technical support vehicles including those for missile check and maintenance/liquid propellant filling/solid propellant charge loading; a power station sub-unit with three power generating vehicles and one power distribution vehicle; and a radar sub-unit with a missile guidance



*HQ-2J variant being launched from its single rail launcher*

station comprising a radar van, a radar control vehicle, a battalion command post vehicle and a maintenance/spare parts vehicle.

The two-stage HQ-2J missile is configurationally similar to the Soviet SA-2 being 10.842 m long and weighing 2326 kg at launch. The diameter of the solid-propellant rocket booster motor stage is 0.654 m and of the high thrust liquid fuelled sustainer rocket-propelled main body stage 0.5 m.

Internally the weapon has been upgraded in terms of electronic systems and fitted with an improved design warhead with a wide multiple fragmentation scattering pattern. The target speed at high altitude can be 750 m/s and at low altitude 420 m/s. The missile can be used in head-on and tail-chase engagements.

The basic all-weather target acquisition/tracking and missile guidance radar used with the HQ-2J has the NATO designation Gin Sling A. In appearance it is similar to the earlier Soviet NATO designation Fan Song system and has a matching performance in the ability to track a single target and guide up to three missiles at it.

### Description (HQ-2B model)

The HQ-2B battalion is a mobile version of the HQ-2J unit and comprises the following components: six trainable single-rail launchers carried on the rear decking of lengthened Type 63 light tank chassis, all the missile/launcher firing controls, power supply systems and necessary electronics are located in the hull area with access provided by latched side panels; 24 missiles (six on the launcher vehicles with the remainder at the battalion

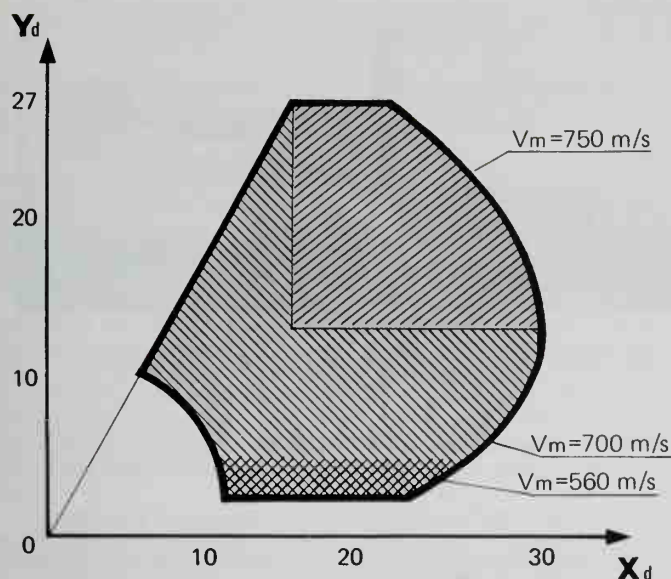


*HQ-2B variant mobile surface-to-air missile system with missile elevated (Eric Ditchfield)*



*HQ-2B missile being prepared for launch on its tracked transporter/launcher platform*





Operational zone of the Chinese HQ-2B SAM extends from an altitude of 1 km up to 27 km with maximum slant range being 35 km. The  $V_m$  on chart is speed of target

reload storage site or on transloader vehicles a variable number of transloader vehicles; and a ZD-2(B) missile guidance station.

The HQ-2B missile is similar to the HQ-2J described previously but is fitted with a moderate dispersion angle HE-fragmentation warhead, an anti-jam digital code radio command guidance system, an integrated circuit autopilot and an FM phase comparison proximity fuzing circuit. The weapon has head-on, crossing target and tail-chase engagement capabilities.

The Single-Shot Kill Probability (SSKP) of a single round a target with a velocity of <565 m/s is 0.92 and against a target with a velocity of <750 m/s 0.73. Targets up to a maximum velocity of 1000 m/s can be engaged.

If required the HQ-2B can be fired from the semi-fixed single-rail launcher assembly used for the other HQ-2 family members.

The ZD-2(B) missile guidance station comprises the following subsystems:

- (1) the 2FA(B) radar receiver-transmitter trailer (believed to have the NATO code name Gin Sling B) which is fitted inside its cabin with:
    - (a) the main E/F-band radar transmitter unit
    - (b) the main E/F-band radar receiver unit
    - (c) an auxiliary I/J-band range measuring radar transmitter
    - (d) a monopulse radar receiver unit
    - (e) an antenna feeder system
    - (f) an antenna servo system.
- On the trailer's cabin roof are the:
- (a) main radar's elevation scan antenna
  - (b) main radar's azimuth scan antenna
  - (c) target illuminator radar antenna
  - (d) the D-band missile command guidance transmitter antenna
  - (e) the secondary telescope and video TV camera tracker head assembly
  - (f) the auxiliary range measuring radar antenna receiver box.

The missile's own tracking transponder system operates in the D-band.

- (2) the 2X(B) truck-mounted display shelter which acts as the combat command centre for the battalion. This contains the IFF display, the video TV tracker and large PPI screen displays, the radar and launcher control systems, the battalion system status displays, main battalion and higher echelon communications and a training engagement simulator system.
- (3) the 2M(B) truck-mounted command communications shelter which is equipped with the battalion and higher echelon signals equipment including the cryptography units for encoding and decoding of signal traffic.

The guidance station can operate in normal main radar target acquisition scan, selected target track and illumination, monopulse (as an ECCM technique) and TV tracking modes. The co-ordinate difference between the target and the missile is obtained by using the relative co-ordinate system in the 2Z(B) shelter truck. The ranges and angle co-ordinates of the target and the missile are also obtainable with the secondary digital tracking system.

Maximum detection range of the main radar system is in excess of 100 km, with a stable automatic tracking range of over 75 km. The maximum auxiliary range measuring capability is in excess of 60 km and the secondary TV tracking range for use in heavy ECM environments is around 45 km.

- (4) the 2Z(B) truck-mounted co-ordinate shelter which carries the TV video and IFF electronics, the co-ordinate tracking system for the targets and



Gin-Sling B radar for HQ-2B surface-to-air missile system deployed

missiles, and a micro-computer for firing solution computations and generation of missile command and control instructions.

- (5) the 2P(B) truck-mounted power distribution centre which carries the distribution board system for the output of the generator trucks. It supplies by cable the power outputs to all the guidance unit subsystems.
- (6) three 2D(B) truck-mounted generator systems (one of which acts as a spare). Each system has one shelter-mounted 50 Hz diesel generator and converter unit to provide 3-phase 50 Hz and 3-phase 400 Hz AC electrical supplies to the power distribution centre truck.

#### Variants

#### HQ-2 systems with the SJ-202 radar set

For use with both the HQ-2 family members and the Soviet SA-2 'Guideline' system CPMIEC has produced the SJ-202 phased-array target acquisition/tracking and missile guidance station comprising a highly automated radar van and a command and control truck. The station is easily integrated with the power generation units of the missile unit to which it is attached.

Maximum detection range is 115 km and tracking range 80 km. Up to four missiles can be guided at any one time to simultaneously attack either one or two targets. Response time is quoted as eight seconds.

#### SPECIFICATIONS (HQ-2B and HQ-2J variants)

TYPE	two-stage low to high altitude
LENGTH	10.842 m
DIAMETER	
booster stage	0.654 m
main body	0.50 m
MAX SPAN	
booster stage	2.5 m
main body	1.7 m
LAUNCH WEIGHT	
HQ-2B	2322 kg
HQ-2J	2326 kg
PROPULSION	solid fuel booster with storable liquid fuel sustainer type
GUIDANCE	command type
WARHEAD	improved (over HQ-1/SA-2) HE-fragmentation with proximity and/or command fuzing systems
MAX SPEED	
HQ-2B	1250 m/s
HQ-2J	1200 m/s
MAX RANGE	
HQ-2B	35 000 m
HQ-2J	34 000 m
MIN RANGE	
HQ-2B	7000 m
HQ-2J	5000 m
MAX ALTITUDE	27 000 m

## MIN ALTITUDE

HQ-2B 1000 m

HQ-2J 500 m

## LAUNCHER

HQ-2B trainable single rail mobile or semi-fixed

HQ-2J trainable single rail semi-fixed

RELOAD TIME 10-15 minutes

**Status:** In production. In service with Albania, People's Republic of China, Iran (eight battalions purchased in early 1989), North Korea and Pakistan.

**Manufacturer:** Chinese state factories.

Export marketing carried out by China Precision Machinery Import and Export Corporation, 17 Wenchang Hutong Xidan, Beijing, People's Republic of China.

Telephone: 895012/831 1804

Telex: 22484 CPMC CN



*SJ-202 guidance station or SA-2 or HQ-2 SAM system deployed*

## CSSC PL-8H/715-I Missile Gun Combination Weapon System

### Development/Description

Early in 1991, the China State Shipbuilding Corporation (CSSC) disclosed details of the prototype of a naval air defence system consisting of the twin 37 mm Type 715-I light anti-aircraft gun mount fitted with two surface-to-air missiles designated the PL-8H, coupled with a fire control system and a tracking radar. Although originally developed for naval applications it is possible that there is also a land version of this system.

The PL-8H missile may well be an exported Israeli Python 3 air-to-air missile, a licence-built version or even a copy of the Israeli missile.

The missiles were mounted on what are almost certainly air-to-air missile launch rails one either side of the twin 37 mm mount.

Python 3 technology would provide an all-aspect infra-red seeker to give the system a head-on engagement capability against aircraft targets.

The probable launch weight of the PL-8H missile is 120 kg and it is expected that the missile will have an 11 kg HE blast fragmentation warhead with an active laser fuze.

The 37 mm automatic anti-aircraft gun system has a maximum range of 9400 m and a maximum altitude of 7200 m, although its effective range is well below this. Cyclic rate of fire is 360/380 rounds per barrel per minute; tracking speed in elevation is 50°/s and in traverse 40°/s. Elevation and traverse is powered. Maximum muzzle velocity of the 37 mm ammunition is 1000 m/s.

The mount is unmanned and would normally only be controlled by a centralised fire control system. Missiles would be launched only within the effective range envelope with typical target interception taking place at a range of 4500 m.

**Status:** Prototype.

**Manufacturer:** Chinese State Shipbuilding Corporation, 5 Yuetan Beijie, Beijing, People's Republic of China.

Telephone: SB 890971

Telex: 22335 CSSC CN/22029 CSSC CN



*Type 715-T twin 37 mm anti-aircraft gun system with PL-8H surface-to-air missiles in the ready to launch position on either side of the mount*



## GERMANY

## MBB/AEG/Siemens TLVS Low to Medium Altitude Surface-to-air Missile System

## Development/Description

The TLVS (*Taktisches LuftVerteidigungsSystem*) is a concept development study for an indigenous medium-range surface-to-air missile system to meet the German Air Force's MSAM requirement for an I-HAWK replacement, to defend airfields and other high value targets.

The system will use a 30 km range all-weather truck-mounted supersonic weapon to counter aircraft, tactical SRBMs, cruise missiles and low observable (stealth equipped) targets.

The MBB developed missile will use inertial guidance first and then switch in its mid-course phase, either on command or automatically, to an AEG J-band active radar seeker for the terminal guidance stage. The latter will have the ability both to discriminate rapidly between targets and to pick out low level targets from ground clutter in what is virtually a look-down mode.

The associated Siemens ground radar is to be a multi-function phased-array system operating in the H/I-band region. It will scan electronically in both azimuth and elevation with coverage in the former being up to 100° at any one time during a single rotation. This maximises the dwell time spent on the target.

If the TLVS is adopted then full-scale engineering development will start in 1994 and initial production in 1999-2000. Operational deployment would follow with the I-HAWK systems being replaced by around 2005.

**Status:** Concept development phase. Study submitted in 1990.

**Manufacturers:** Prime contractor (and for missile and launch unit): Messerschmitt-Bölkow-Blohm GmbH (MBB), Dynamics Group, PO Box 801149, D-8000 Munich 80, Federal Republic of Germany.

Telephone: (89) 6000-2206

Telex: 52870 mbbd

Active radar seeker: AEG Aktiengesellschaft, Theodor-Stern-Kai 1, D-6000 Frankfurt/Main, Federal Republic of Germany.

Telephone: (69) 6001

Telex: 411076

Cable: ELEKTRON WEST

Radar and fire control system: Siemens AG, Radio and Radar Systems Division, Landshuter Str 26, D-8044 Unterschleissheim, Federal Republic of Germany.

## INTERNATIONAL

## EUROSAM Future Surface-to-air Family (FSA)

## Development

The feasibility studies for the French SYRINX programme (*système rapide interarmées à base d'engins et fonctionnant en bande X*: X-band fast tri-service missile system) were carried out from 1982-1984. Pre-development contracts were awarded in 1984 to Thomson-CSF for the Arabel radar and fire control system, and to Aerospatiale for the ASTER missile family. These were followed by full development contracts in 1988. The SYRINX system is designed to defend against aircraft, air-to-surface missiles, surface-to-surface missiles and cruise missiles, with the possibility of further development to defend against short-range ballistic missiles.

The Arabel fire control I/J-band radar is a 3D phased-array system scanning 360° in azimuth and 75° in elevation, capable of both surveillance and tracking functions, as well as passing update information to missiles in flight. Four ASTER missile versions are planned: SAAM (*système naval d'autodéfense moyen portée*: naval surface-to-air anti-missile system) to be met by the ASTER 15, SAMP *terrestre* (*Système sol-Air Moyenne Portée*: land-based medium-range surface-to-air missile) and SAMP *naval* (*Système sol-Air Moyenne Portée*: ship-based medium-range surface-to-air missile) which will both be met with the ASTER 30, and finally a fourth version to be capable of intercepting tactical ballistic missile targets.

The SAMP land and naval versions will have additional sensors to augment the Arabel radar, including a secondary search radar and optical systems to assist with identification and provide better performance in heavy ECM environments. It is planned for the SAMP fire control system to be able to handle up to 10 simultaneous missile interceptions, in a largely automatic system.

Following an October 1988 joint production agreement between the Defence Ministers of Italy and France, Aerospatiale, Thomson-CSF and Alenia signed, in June 1989, the EUROSAM Groupement d'Intérêt Economique (GIE) consortium agreement to produce the Future Surface-to-air Family (FSAF) of land and seaborne weapon systems designed to meet the needs of both countries' armed forces. These systems were:

- (1) SAAM/France (Aster 15/Arabel): SAAM/Italy (Aster 15/Empar) shipboard point defence missile system. Operational date 1996-98, French and Italian navies.
- (2) SAMP/Terrestre (Aster 30/Arabel) medium surface-to-air missile system. Operational date 1998, French and Italian armies; French Air Force.
- (3) SAMP/Naval (Aster 30/Empar) combined shipboard point defence missile system and medium surface-to-air missile system. Operational date 1998-2000, various European navies.

The fire control systems will use either the Thomson-CSF Arabel or the Alenia Empar G/H-band radar as outlined above.

The highly jam-resistant Empar multi-function single antenna radar is intended to cope with multiple targets arriving from any direction and be able to provide mid-course guidance signals to the Aster 15/30 missiles (given suitable guidance modifications) within the radar signals. Pulse-to-



Launching of Aster missile with trajectory firing

pulse frequency agility over a range of 10 per cent of the frequency band centred on 5.6 GHz is available. The antenna rotation rate is 60 rpm.

The detection range on a 2 m<sup>2</sup> radar cross-section target is about 100 km and between 50-60 km on a 0.1 m<sup>2</sup> target. Volumetric search tracking and identification at any altitude are provided with a horizon search capability to look for 'pop-up' targets.



Close up of the Thomson-CSF Arabel radar



Artist's impression of SAMP deployed in the field with launcher left, fire control unit centre and Arabel radar unit right. In a combat situation the units would be well spread out with the launchers being up to 5 km from the other components of the system



Aster missile dart on concept launch firing with trials booster section

The tracking system will be able to handle up to 36 high priority targets, which can include 'own' missiles in-flight and lower priority targets. For use with the Aster 30 a separate surveillance radar is required to provide both area coverage and own aircraft control.

The EUROSAM GIE has been awarded a study contract for the project definition of the Local Area Missile System (LAMS) on behalf of the United Kingdom, Spanish, French and Italian Governments. LAMS is one of the requirements of the naval Family of Anti-air Missile Systems (FAMS).

In addition, Spain will enter the GIE EUROSAM before the end of 1991 with the participation of the INSEL consortium, for the development and production of FSAF systems.

#### Description

The all-weather SAMP/T missile system will be used for area defence on the battlefield and the protection of Vital Points against mass strikes by aircraft and/or missiles at all altitudes.

The basic SAMP/T has an inherent Anti-Tactical Ballistic Missile (ATBM) interception capability against various types of missiles (for example, SRBMs of the SS-21 Scarab type, diving Mach 3.5 Anti-Radiation Missiles (ARMs) and very low altitude cruise weapons). The engagement range is between 10 and 20 km depending upon the missile's characteristics.

Against highly manoeuvrable Mach 2.5 aircraft targets at various altitudes the range increases to approximately 30 km, whilst for slow and poor manoeuvring targets like Stand-Off Jammers (SOJ) and other similar battlefield/strike support aircraft, the engagement range can further be increased to approximately 90 km by the use of a semi-ballistic flight trajectory.

The heart of the system is the 60 rpm Arabel 3D frequency-agile 70 km range narrow beam radar already mentioned. This scans electronically, both in azimuth and elevation, to provide multi-target tracking and missile guidance data channel uplinks on a time-share basis.

Arabel can accurately track up to 100 targets at any one time and provide the necessary information for the simultaneous engagement of up to 16 of them.

The minimum reaction time from initial radar detection to first missile launch is only four seconds.

The operational engagement sequence is:

- (a) first detection plus immediate detection confirmation leads to a track initialisation
- (b) target identification via IFF subsystem and, if hostile, track formation
- (c) threat evaluation (and priority assigned if more than one)
- (d) target designation and missile launch
- (e) inertial mid-course missile guidance
- (f) active radar terminal missile guidance
- (g) target interception.

The ASTER 30 missile used is vertically launched and has a tandem first stage solid propellant booster that is jettisoned in flight.

The missile itself can manoeuvre at up to 50g and has four long rectangular wings, and four moving clipped-tip control fins at the rear for aerodynamic flight control (*Pilotage Aérodynamique Fort*—PAF). Additional manoeuvrability in the terminal flight phase is provided by a gas generator exhausting through four lateral nozzles close to the missile's centre of gravity (this system is known as *Pilotage en Force*—PIF).

Guidance in the mid-course phase is inertial, with the addition of commands from the fire control centre being sent via the Arabel's antenna and the uplink data channel. This flies the missile out on a reciprocal course to the target's vicinity where the active radar seeker is activated.

This is derived from the Dassault Electronique AD4A homing head design of the Matra MICA air-to-air missile and uses a centimetric J-band pulse Doppler seeker to guide the missile on an optimised, proportional navigation low flight path to the target.

A HE-blast fragmentation warhead with parallel distribution characteristics is then triggered by the weapon's calculated proximity delay fuzing circuit. This ensures that the missile is in very close range (about 2 m) to the target when the warhead detonates so as to guarantee its structural destruction. It is also the reason for the additional PIF flight control system used just before impact, as this enables targets performing up to 15g evasive manoeuvres to be successfully destroyed.

The SAMP/T fire unit is expected to be truck-mounted on Renault TRM 10 000 (6 × 6) vehicles with a two-station automatic fire control module vehicle, an Arabel radar vehicle with retractable antenna, optional secondary radar, electro-optics and communications/IFF subsystem vehicles and four to six missile Transporter-Erector-Launcher (TEL) vehicles.

The TEL will have eight canisterised ready to fire vertically launched ASTER 30 missiles. Distance of the launchers from the radar will be up to 5 km in order to increase the fire unit's survivability.

The complete fire unit is airportable and can be deployed in combat configuration in 10 minutes.

To cope with steeply diving tactical ballistic missiles, the ASTER 30 and the Arabel fire control technology is being modified to produce an ATBM missile variant.

The modified missile is known as the ASTER 30 ATBM and is designed to engage the second-generation of TBMs. The basic SAMP/T missile is already considered satisfactory for engaging first-generation TBMs even if they attempt manoeuvring.

A further missile variant to cope with extended engagement ranges and full efficiency against manoeuvring second-generation TBMs is called the



ASTER Extended Range (ASTER ER). This missile development involves significant changes to the ASTER 30 booster section to improve performance characteristics.

# SPECIFICATIONS

TYPE	ASTER 15	ASTER 30
	two-stage short-range	two-stage medium-range
LENGTH		
missile	2.6 m	2.6 m
booster	1.6 m	2.2 m
total	4.2 m	4.8 m
DIAMETER		
missile	0.18 m	0.18 m
booster	0.36 m	0.54 m
WEIGHT		
missile	100 kg	100 kg
booster	300 kg	450 kg
total	400 kg	550 kg
PROPULSION	two-stage solid propellant booster rocket and ramjet sustainer motors	
GUIDANCE	inertial mid-course with command update and terminal active J-band radar	

# WARHEAD

MAX SPEED  
MAX RANGE  
LAUNCHER

HE-blast  
fragmentation  
with calculated  
delay proximity  
fuzing  
1100 m/s 1400 m/s  
see text  
8-round semi-  
mobile vertical  
launch  
8-cell mobile  
vertical  
launcher

**Status:** Under development to meet requirements of French and Italian armed forces.

**Manufacturers:** Thomson-CSF, Division Systèmes Electroniques, 9 rue des Mathurins, F-92223 Bagneux Cédex, France.

Telephone: (1) 40 84 40 00  
Telex: 204 780 F

Aerospatiale, Division Engins Tactiques, 2 rue Béranger, F-92322 Chatillon Cédex, France.

Telephone: (1) 47 46 21 21  
Telex: 250 881 F

Alenia, Industrie Elettroniche Associate SpA, Defence Systems Group, Via Tiburtina Km 12.400-00131 Rome, Italy, PO Box 7083-1000.

Telephone: (39-6) 40971  
Telex: (43) 613 690 SELROM-I

## Skyguard/Sparrow Air Defence System

### Development

This air defence system is a joint development between Oerlikon-Contraves of Switzerland and Raytheon of the United States and combines two proven systems, the Skyguard fire control system, normally used to control Oerlikon-Contraves twin 35 mm GDF series towed anti-aircraft guns and the Raytheon AIM-7E/AIM-7F/AIM-7M Sparrow missile, which in its normal application is air-launched.

Typically, the missile would be used to engage targets at long-range with the guns used at ranges of 4000 m or less.

A variant of the AIM-7E, designated RIM-7E-5, is used in the surface-to-air role with the US Navy as part of its Basic Point Defense System. Another variant, the RIM-7H-5, is used in the NATO Sea Sparrow Surface Missile System. More recently, the RIM-7M has been adopted by the US Navy with the RIM-7P as the follow-on weapon.

In 1982 the Egyptian Air Defence Command ordered 18 battery sets of the Skyguard/Sparrow air defence from Contraves (Italy) to equip three autonomous air defence brigades. The first deliveries were made in December 1984 and final deliveries were in 1987. Egypt calls the system Amoun and a typical section consists of one Skyguard fire control system, two Oerlikon-Contraves GDF-003 twin 35 mm towed anti-aircraft guns and two four-round Sparrow SAM launchers. One section can engage three targets at once, two with missiles and one with guns. Reaction times are 4.5 seconds for the guns and 8 seconds for the Sparrows.

The system delivered to Egypt has some 16 modifications, including a new search antenna unit to reduce the effects of clutter, a new computer and software and a revision of the operator's console to incorporate three operators. Optical target detection range is 15 km and radar range 20 km.

Egypt is understood to have a requirement for additional Amoun sections so that the remaining obsolete Soviet-supplied systems can be phased out of service. Further orders would involve a more significant proportion of local production which was minimal in the initial order.

Prior to this, Greece selected the system under the name Velos in 1983 using RIM-7M missiles. The first was delivered in October 1984 and in October 1985 Spain ordered 13 Italian Selenia Spada launchers and 200 Aspide missiles for integration with existing Skyguard fire control systems and Oerlikon-Contraves twin 35 mm GDF-005 towed anti-aircraft gun batteries. The Aspide missiles were already used by the Spanish Navy on its frigates. Total value of this contract was \$220 million and included Spanish co-production.

The first battery was delivered by Oerlikon-Contraves with the remaining six assembled at the Bazan factory in Spain. Marconi Spain was responsible for modification kits and the launcher electronic groups and EISA manufactured the electrical cables. Bazan produced the missile container and the launcher's electrical and mechanical components.

The Spanish name for this system is Toledo. All systems were delivered by the end of 1989. As the Spanish Skyguard fire control systems were delivered in the late 1970s, the contract also covered the supply of seven modification packages to bring these up to the latest configuration.



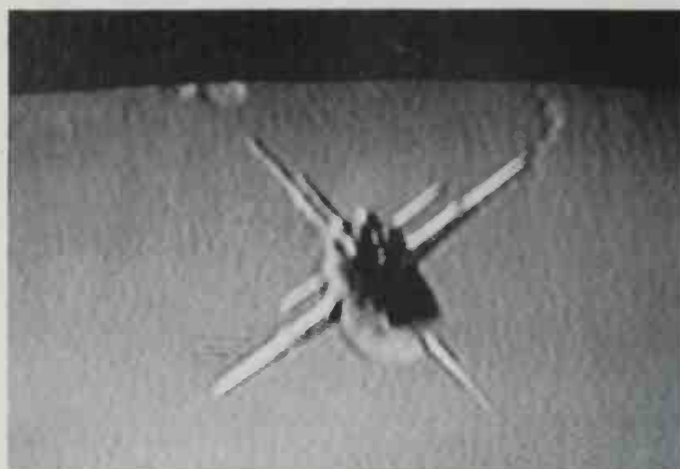
Typical Skyguard/Sparrow/twin 35 mm air defence battery with Oerlikon-Contraves Skyguard fire control system, left, two twin four-round Sparrow SAM launchers and two twin Oerlikon-Contraves GDF series 35 mm anti-aircraft gun systems



Close up of launcher showing two Sparrow missiles in their transport/launcher containers each side of the operator's position with illuminator antenna mounted forward and below his position



Rear view of four-round launcher for Sparrow missiles. Carriage is identical to that employed in twin 35 mm Oerlikon-Contraves anti-aircraft gun which is also deployed in battery



This photograph, taken from a TV camera mounted on the target drone and relayed to a ground-based monitor, shows the Sparrow missile a split second before target impact

The 1st Group of the 73rd Air Defence Regiment is equipped with Toledo. The unit is deployed in south-west Spain and is assigned the air defence of the Army's 3rd Mechanised Division and the Spanish Navy's base at Cartagena. The 1st Group has three batteries with a total of six Super Skyguard fire control systems, twelve GDF twin 35 mm anti-aircraft guns and twelve Toledo four-round launchers. The remaining Skyguard fire control system and Toledo launcher are assigned to the Spanish Army's Artillery School, with two Roland systems, for training duties.

Tactical firing trials of the Skyguard/Sparrow were carried out in October 1980 at the Naval Weapons Center, China Lake, California. Three missiles, one AIM-7E and two AIM-7Fs, were fired against remotely controlled aircraft targets, Northrop QT-38 Talon for the AIM-7E and North American QF-86 Sabre for the AIM-7F.

The AIM-7E was not fitted with a warhead, but intercepted the target and passed well within the lethal radius of the warhead. The first AIM-7F was fitted with a telemetry pack in place of the warhead, but scored a direct hit on the right underwing fuel tank. The second AIM-7F hit the front fuselage of the target causing extensive damage to the air intake and cockpit. The drone aircraft then went out of control and subsequently crashed.

In 1980 a demonstration of the Skyguard/Sparrow took place at the NATO Missile Firing Range (NAMFI) in northern Crete using production equipment that had already been delivered to a customer.

A remotely piloted Northrop Chukar target drone, which has roughly the dimensions and speed of some cruise missiles, was used as a target. The drone approached the weapon position at an angle from the front, flying 700 m over the weapon site at a speed of more than 200 m/s. The first launch scored a physical hit at more than 12 km range sending the drone into the sea. In the second intercept the missile flew past the new drone at a 1 m distance; since the Sparrow missile would have been triggered by its proximity fuze in a real engagement, this was considered a kill.

The Skyguard/Sparrow combination has also been sold to Taiwan.

In mid-1991 Oerlikon-Contraves states that an AIM-7F missile, launched under Skyguard control from an Oerlikon-Contraves SAM launcher for a customer force in May 1991, scored a direct hit when it shot down a target

drone flying at a speed of approximately 200 m/s at a range in excess of 10 km.

The latest success was achieved within a customer specified system acceptance test programme which involved one dry rehearsal and one hot firing against a target drone flying at high subsonic speed. The weather conditions prevailing at the time of the test were described as marginal with reduced visibility, rain and heavy gusts.

#### Description

The Skyguard (additional details of which are given in the entry for the Oerlikon-Contraves twin 35 mm GDF towed anti-aircraft gun) carries out search and identification using a 20 km I/J-band radar, tracks the selected target by radar using a pulse Doppler K-band set or TV, computes intercept to facilitate the engagement and then aims the launcher at the target via digital data cable transmission.

The four-round launcher is mounted on the carriage of the Oerlikon-Contraves twin 35 mm GDF towed anti-aircraft gun system and the missiles are fired through the covers. The folded wings deploy after separation.

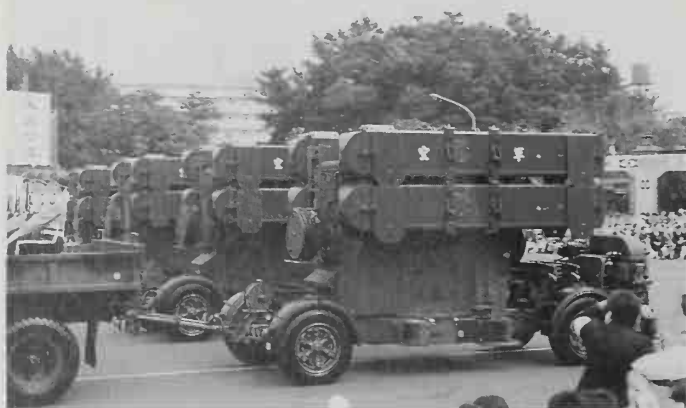
Two rounds are mounted each side of the operator's position with the illuminator antenna mounted forward and below his position.

The I-band illuminator provides continuous wave illumination of the target out to 13 km (20 km in the case of Egyptian systems) and the missile's seeker homes on the reflected signal.

#### Variants

##### Skyguard/Aspide

This is similar to the Skyguard/Sparrow but uses the four-round Aspide launcher used in the Spada air defence system in service with Italy and Thailand. The system was successfully demonstrated in 1981 and subsequently adopted by Spain under the name Toledo, which already has the Skyguard and twin 35 mm guns in service.



Taiwanese Skyguard Sparrow four-round launcher in travelling configuration (L J Lamb)



Sparrow SAM being launched under control of Skyguard fire control system



**SPECIFICATIONS (AIM-7F) (missile)**

TYPE	single stage, low altitude
LENGTH OF MISSILE	3.66 m
BODY DIAMETER	0.203 m
WINGSPAN	1.02 m
MAX RANGE	13 000 to 20 000 m (depending upon illuminator radar range)
MAX ALTITUDE	5000 m
MIN ALTITUDE	15 m
LAUNCH WEIGHT	233.6 kg
PROPULSION	single stage, solid propellant
GUIDANCE	I-band semi-active radar homing
WARHEAD	39 kg HE fragmentation with contact and proximity fuzing
SPEED	Mach 2.5

**Status:** Production as required. In service with Egypt (18 batteries, Air Defence Command), Greece (20 batteries, Air Force manned), Spain (7 batteries, Army manned with Aspide missiles) and Taiwan.

**Manufacturers:** Oerlikon-Contraves AG, Schaffhauserstrasse 580, CH-8052 Zurich, Switzerland.  
Telephone: (01) 306 22 11  
Telex: 823 402 coz ch  
Fax: (01) 301 34 66

Raytheon Company, Missile Systems Division, Bedford, Massachusetts 01730, USA.  
Telephone: 617 274 222

**IRAQ****Modified SA-2 'Guideline' Surface-to-air Missile System****Development/Description**

In mid-1989 Iraq announced that it had fitted a Soviet supplied SA-2 'Guideline' surface-to-air missile system (qv) with an infra-red terminal guidance system.

According to Iraq this increases the missile's ability against highly manoeuvrable targets at high altitude, especially those using electronic countermeasures.

The nose-mounted seeker senses the thermal radiations of the target at the final stages of missile guidance so enabling the missile to transfer from the normal radio-command guidance system to infra-red homing guidance.

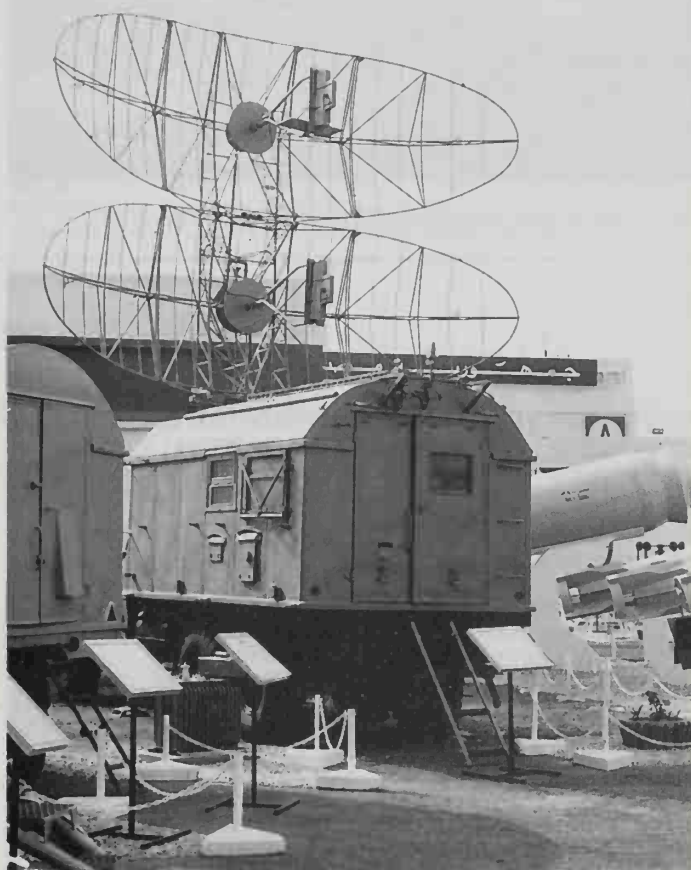
If, however, the thermal sensing is lost at this stage then guidance can quickly revert back to radio-command guidance.

**Status:** Following the 1991 Middle East conflict the status of this system is uncertain.

**Manufacturers:** Missile: Soviet government facilities. Modifications: Iraqi government facilities.



*Iraqi modified SA-2 'Guideline' SAM fitted with infra-red terminal seeker*



*Soviet supplied Flat Face surveillance radar used with SA-2 'Guideline' surface-to-air missile system*



*Soviet supplied Fan Song E radar used with SA-2 'Guideline' surface-to-air missile system*

## Other Iraqi Surface-to-Air Missiles

Iraq uses a large number of surface-to-air missile systems which, with the exception of the Euromissile Roland, are of Soviet origin.

In addition to the modified Soviet SA-2 'Guideline' with an infra-red seeker (see previous entry), Iraq has modified a number of other systems and brief details of these are given below:

Iraqi name	Missile
Barq	Soviet SA-3 'Goa' modified for use in ground/ground role
Fahad 300	surface-to-air missile modified for use in ground/ground role with range of "hundreds of kilometres"

**Iraqi name**  
Fahad 500

Faw-1

Kaser

### Missile

surface-to-air missile modified for use in ground/ground role

Soviet SA-2 'Guideline' modified to engage surface-to-surface missiles. This has already been tested in Iraq but is not believed to have entered production

Soviet SA-6 'Gainful' modified for use in ground/ground role



SA-3 'Goa' modified for ground/ground role and called Barq



Surface-to-air missile modified for use in ground/ground role and called Fahad 300

## ISRAEL

### Israel Aircraft Industries Chetz (Arrow) Anti-tactical Ballistic Missile (ATBM) System

#### Development/Description

As part of the US Department of Defense (DoD) Strategic Defense Initiative (SDI) research and development effort, an initial demonstrator contract was placed with Israel Aircraft Industries (IAI) Electronic Division in July 1988 to develop, manufacture, integrate and flight test four prototypes of the solid propellant Chetz (Arrow) ATBM together with its early warning, guidance and proximity fuzed warhead subsystems.

Total cost of the initial contract was \$158 million with the US DoD funding 80 per cent and the Israeli MoD the other 20 per cent. The system is designed to counter both air breathing threats and SRBMs of up to 1000 km in range by intercepting them in the final stage of their flight trajectory at altitudes of up to 30 000 m and at a range of up to 90 000 m.

Elta, an IAI subsidiary, has been chosen to develop a combined early warning and fire control radar. The latter component will use an active array which is electronically scanned in elevation and azimuth.

Rafael, the Israeli weapons development authority, was awarded the contract to develop the Arrow's warhead.

In January 1989 it was announced that Lockheed Missiles and Space Company had signed an agreement with IAI to involve itself in the follow-up full-scale development and production phases following a successful completion of the demonstrator test programme.

The first demonstration flight was flown at an Israeli Mediterranean Sea test range in August 1990. The second flight took place in March 1991, the third in October 1991 and the projected fourth by the end of April 1992.

The second stage of development will last 45 months and cost some \$340 million, 72 per cent to be paid by the US DoD and 28 per cent by the Israeli Defence ministry. A total of 11 test flights are planned. However, due to problems experienced during the second and third full-scale test flights the programme is likely to be delayed by up to 12 months or so.

**Status:** Development phase.

**Manufacturer:** Israel Aircraft Industries (IAI) Ltd, Electronic Division, Yahud Industrial Zone, I-56000 Yahud, Israel.

Telephone: (3) 357211

Telex: 341450

Cable: ISRAELAVIA



Launch of Arrow anti-tactical ballistic missile during first test flight



## ITALY

## Alenia Spada Low Altitude Surface-to-air Missile System

### Development

In the 1960s the Indigo short-range surface-to-air missile system was developed by Sistel with a typical firing unit consisting of a Contraves Superfleddermaus fire control centre, Contraves LPD-20 acquisition radar and two Sextuple Indigo towed missile launchers. This was never placed in production, nor was a self-propelled version on an M548 tracked carrier which used the same missiles, but a new fire control system with Officine Galileo acquisition and tracking radars.

The Spada point defence missile system was developed in the 1970s to meet an urgent Italian Air Force requirement for a low level air defence system to defend air bases and other key areas.

To reduce both development time and costs, it was decided to use components already proven in other applications; for example, the Aspide Mk 1 missile is identical to that used in the naval air defence role, the SIR is a modified Selenia Pluto E/F-band radar system and the TIR pulse Doppler radar has been developed from the naval Alenia Orion 30X radar tracker incorporating a J-band illuminator which has been in widespread service for some years.

Trials with the first prototype system were completed in 1977 with full technical and operational evaluations undertaken by the Italian Air Force during 1982 and 1983.

By 1986 a total of 12 systems had been ordered by the Italian Air Force with the first battery becoming operational in 1983. Total procurement will be four battalions, each with four batteries of six launchers apiece. A further four batteries will be procured as part of the offset compensation programme associated with the Patriot purchase agreement to protect the four USAF bases in Italy.

In 1986 the Royal Thai Air Force ordered one complete Spada battery which was delivered in 1988. The Royal Thai Navy already has the Aspide missile used in its Albatros naval point defence system.

Key features of the Spada point defence system have been summarised by Alenia as large area of cover with high single shot kill probability, flexibility in system configuration, deployment and sighting, good co-ordination, reliable target identification capability, high resistance to enemy ECM and the possibility of being integrated into a national air defence system.

### Description

A typical Spada battery has two main components, the Detection Centre (DC) and the Firing Sections (FS). The detection centre consists of the Search and Interrogation Radar (SIR) which comprises the SIR antenna pedestal and its equipment shelter and the Operational Control Centre (OCC) shelter, plus a generator.

One DC controls two firing sections, each of which comprises the Fire Control Centre (FCC) consisting of the Tracking and Illuminating Radar (TIR) antenna pedestal with its TV sensor, Control Unit (CU) shelter for the TIR and firing control equipment, a generator and two Missile Launchers (ML) each with six missiles in the ready to fire position.

The firing sections can be up to 5 km from the DC and the configuration of the battery is flexible from one to four firing sections, each equipped with up to three six-round missile launchers.

The Aspide Mk 1 missile has an intercept envelope extending out to a range of 18 000 m to an altitude of 6000 m with an SSKP of not less than 0.7. Overall reaction time on first target is in the order of 10 to 15 seconds and of about 5 seconds on the following target.

The largest size battery can cover an area of up to 800 km<sup>2</sup> with a maximum of 72 missiles in the ready to launch position which can be fired singly or in salvos of two.

The task of the DC is to search for targets, identify, evaluate and designate them to the FS. Through the SIR, targets in the area covered are searched for, detected, plot extracted and selectively IFF interrogated. Tactical control of the battery is achieved by means of the associated OCC. Plot initiation, track-while-scan and data updating of a number of tracks, their identification, threat evaluation and target designation to the FS for engagement are carried out.

All the operations listed above are carried out automatically by the system.

The SIR consists of a low altitude search radar, particularly suitable for dense clutter environments, and advanced ECM and an interrogation radar with decoding capability on IFF answers.

The OCC consists of three operational consoles, a data processing system with two NDC-160 interconnected computers and a number of digital and phonic operational communication links.

The main tasks of the three OCC operators are checking for correctness of the various automatic operations, setting up the zones in which automatic plot extraction and track initiation should or should not take place, manual intervention to substitute for or correct automation, particularly in the presence of ECM, and selection of battery intervention criteria.

### Search and Interrogation Radar

#### SPECIFICATIONS (search radar)

FREQUENCY BAND	F
ANTENNA TYPE	supercosecant square
TRANSMITTER	coherent chain, TWT final stage
WAVEFORM	coded
PRF	staggered
FREQUENCY AGILITY	pulse-to-pulse or burst-to-burst
MTI	double canceller, frequency agility compatible

#### SPECIFICATIONS (IFF interrogation radar)

ANTENNA	integrated with the search radar antenna
SLS	included
SIF modes	1, 2, 3/A
MARK XII IFF	compatible

### Operational Control Centre

#### SPECIFICATIONS (operational console)

16 in CRT display for synthetic and raw radar data
7 in CRT display for alphanumeric data
Man/machine interfaces (keyboard, control panel, trackball on-line and off-line BITE)



Alenia Aspide missile being fired from Spada system launcher



Alenia TIR used at each firing section with TV sensor to its left



Six-round Aspide missile launcher in travelling configuration being towed by truck fitted with hydraulic crane for missile resupply

#### SPECIFICATIONS (NDC-160 computer)

MAGNETIC CORE MEMORY	32 K words of 16 bits plus 2 bits parity
CYCLE TIME	1.10 $\mu$ s
ARITHMETIC INSTRUCTIONS	binary, parallel two-complement
INPUT/OUTPUT INTERFACE	121
INPUT/OUTPUT CHANNELS	synchronous
OPERATIONAL DIGITAL COMMUNICATIONS	up to 62

#### EXCHANGE SPEED

Serial link in full-duplex with four wires  
up to 50 Kbit/s for direct links,  
600/1200 bit/s for modem link

#### OPERATIONAL PHONIC COMMUNICATIONS

(inside the system) up to 4 lines  
(outside the system) up to 2 lines  
(logistics) up to 6 lines

The task of the FS, which represents the reaction centre of the system, is to acquire and destroy assigned targets. At the FCC, TIR performs target acquisition, tracking and illumination for missile guidance. As an additional mode of operation, the TIR provides for target search (all round or sectorial scan), detection and self-designation. The TV set is used both as a backup to the radar and as an aid for target identification and discrimination and for kill assessment. The associated CU supervises the above-mentioned functions. Automatic or manual control of the firing action by means of displays and communications equipment is also monitored.

The MLs provide for missile storing, aiming, selection and setting to fire, as well as for automatic launching sequence of the six missiles on each launcher.

The TIR consists of a tracking pulse radar, a CW transmitter for illumination and a common antenna with its own pedestal.

The CU consists of an operational console, a data processing system making use of an NDC-160 computer and a number of digital and phonic operational communication links.

The ML consists of a slewable stand, which supports a frame type structure on which two rows of three missile canisters each are located. This structure can be moved in elevation, both for positioning to the firing angle and for canister loading/unloading operations.

The main tasks of the FCC are setting the FS in stand-by status, checking for correctness of the various automatic operations, providing



Heart of Spada low level air defence system is the detection centre with its Pluto SIR which is a modified Alenia Pluto E/F-band radar

manual intervention when required, missile firing according to the criteria selected by the OCC, and kill assessment.

#### Fire Control Centre (FCC)

##### SPECIFICATIONS (tracking radar)

FREQUENCY BAND	I
ANTENNA TYPE	monopulse
TRANSMITTER	coherent chain, TWT final stage
PRF	staggered
FREQUENCY AGILITY	pulse-to-pulse or burst-to-burst
MTI	quintuple canceller, frequency agility compatible

##### SPECIFICATIONS (illuminator)

FREQUENCY BAND	J
ANTENNA	same as for tracking
TRANSMITTER	klystron oscillator
OPERATIONAL CONSOLE	same as for OCC plus A/R presentation on 7 in CRT and fire pushbutton
	same as for OCC

##### NDC-160 COMPUTER OPERATIONAL DIGITAL COMMUNICATIONS OPERATIONAL PHONIC COMMUNICATIONS

same as for OCC  
(inside system) 1 line (outside system) 1 line (logistics) up to 4 lines

Derived from the US Raytheon AIM-7H Sparrow air-to-air missile, the Aspide Mk 1 missile is a J-band semi-active homing weapon able to guide itself onto the target by sensing the CW electromagnetic energy, either reflected by the illuminating target or emitted by a self-screening jammer.

Propelled by a Difesa e Spazio high thrust single stage, solid propellant rocket motor, the missile uses proportional navigation to direct itself by collision course towards the target.

According to Alenia, the guidance accuracy (due to the adoption of the monopulse inverse type radar receiver) and the active radar proximity fuze and the sizeable Difesa e Spazio pre-fragmented type warhead assures a high SSKP, even in the presence of a dense and sophisticated ECM environment and at very low altitude.

The electrical and hydraulic power generator of the Aspide missile has been developed by Microtecnica and is powered by a solid propellant gas generator. It consists of a high speed gas turbine, reduction gears, an alternator and a hydraulic pump. The hydraulic system is a closed-loop, ensuring the availability of full hydraulic power for the entire duration of guided flight.

The missile is housed and fired from a canister which is also used for transportation and stowing.

In addition to engaging aircraft and helicopters, Spada has a capability against RPVs and air-to-surface missiles.

The air-to-air version is hypersonic and the surface-to-air version is supersonic. They have many common components although their fore and aft fins are different, the former being movable and the latter fixed.

The launcher has six rounds in the ready to launch position and when in the firing position is supported on four outriggers that can be adjusted for height. The launcher can be traversed through 360° at a slew rate of 50°/s with elevation up to 30°.

Reload rounds in their containers are loaded with a hydraulic crane carried on the missile resupply vehicle.

The main components of the Spada point defence system, such as the shelters and fire units, are coupled to a mobiliser wheeled system with the units then towed behind trucks. The mobiliser basically consists of two



The Alenia Aspide Mk 1 multi-role missile



pairs of wheels which are connected to the ends of the shelters as well as both the SIR antenna and the missile launchers.

In addition the shelters and SIR antenna platform can be autonomously loaded/unloaded from a truck by means of a positioning device that consists of four lifting legs which are fitted as standard.

Production of the Aspide Mk 2 missile, with an active pulse Doppler radar seeker head, is scheduled to begin in 1995 with first deliveries in 1996.

#### Variants

The Skyguard/Aspide point defence system is an integration between the Contraves Skyguard fire control system, Oerlikon-Contraves twin 35 mm towed anti-aircraft guns and the Selenia Aspide missile. The tracker and illuminator radar installed on the launcher were developed by Selenia. (There is a separate entry in this section for the Skyguard/Aspide — or Sparrow — point defence system.)



#### SPECIFICATIONS (missile)

TYPE	single stage, low altitude
LENGTH OF MISSILE	3.7 m
BODY DIAMETER	203 mm
WINGSPAN	680 mm
LAUNCH WEIGHT	220 kg
PROPULSION	single stage, solid propellant
GUIDANCE	semi-active radar homing
WARHEAD	HE fragmentation with contact and proximity fuzing
SPEED	around Mach 2.0
MAX RANGE	greater than 15 000 m
MAX ALTITUDE	greater than 6000 m
MIN ALTITUDE	less than 18 m

**Status:** In production. In service with the Italian Air Force. One battery (of four 6-round launchers, two fire control centres with tracking and illumination radars, two search and interrogation radars and one operations control centre) delivered to the Royal Thai Air Force in 1988.

**Manufacturer:** Alenia SpA, Defence Systems Group, Via Tiburtina Km 12.400 - 00131 Rome, Italy. PO Box 7083 - 00100.  
Telephone: (39-6) 40971  
Telex: (43) 613690 SELROM-I

*Alenia SPADA operational control centre*

## JAPAN

### M-SAM Surface-to-air Missile System

#### Development/Description

During October 1990 it was revealed that the Japanese Defence Agency's Technical Research and Development Institute, the Gijutsu-Kenkyu-Honbu, in conjunction with several Japanese companies had started development work on an indigenous Medium Surface-to-Air Missile (M-SAM) system to replace the current Japanese Ground Self-Defence Force I-HAWK units. Contracts have already been placed with the companies to begin component R&D work.

The project definition phase is due to start in FY93. According to the Japanese Defence Agency development is due to be completed by 1997

with flight testing to end in 1997. Production of the system will then begin in the year 2000 and operational deployment in 2002. The missile will feature an anti-tactical missile capability and be fitted with a terrain-following guidance system.

In the meantime, the Japanese Ground Self-Defence Force modernisation programme will continue to convert its I-HAWK systems to the Product Improved HAWK configuration, and both new build already deployed Japanese Patriot Fire Units will be configured to a common standard to give capabilities similar to those of the US Army Patriot PAC-2 system.

**Status:** Initial development phase.

### Type 81 Tan-SAM Low Altitude Surface-to-air Missile System

#### Development

The requirement for the Tan-SAM missile system (Tan is the Japanese word for short) was generated in 1966 when a replacement for the US-supplied divisional level static 75 mm M51 Skysweeper and self-propelled M15A1 37 mm/12.7 mm anti-aircraft guns was requested by the Japanese Ground Self-Defence Force (JGSDF).

System research and fabrication of basic prototype systems was undertaken in 1967-68 with actual construction of experimental units taking place in 1969-70. The first complete prototype systems were built between 1971-76 with the technical testing of the individual system components taking place during 1972-77. In 1978-79 the operational tests of the complete system were undertaken and upon their successful conclusion the JGSDF standardised the Tan-SAM as the Type 81 short-range surface-to-air missile system in late 1980 and began placing yearly production contracts with its manufacturer Tokyo Shibaura Denki Company (Toshiba Electric).

As part of the current JGSDF plans, each of its divisional groups will be assigned four fire units of Tan-SAM systems with the first deployments already made to the four divisions located on the northern island of Hokkaido.

A fire unit comprises one fire control system (FCS) vehicle, two quadruple-launcher vehicles and a few support vehicles with a total team of 15.

During the mid-1970s, the Japanese Air Self-Defence Force (JASDF)

began a project to increase the survivability of its airfields in terms of both active and passive defences. The Tan-SAM was chosen to provide the outer defence ring against enemy aircraft that had 'leaked' through the forward interceptor and area defence SAM barriers whilst the General Dynamics FIM-92A Stinger and the Nippon Steel Works Company licence-built 20 mm M167 Vulcan Air Defence System provided the progressively shorter-ranged second and third line point defence rings.

The first JASDF bases to be so equipped are the five interceptor airfields which are being assigned two fire units of Tan-SAM systems each. Both the JGSDF and the JASDF have also taken delivery of two additional fire units which have been exclusively assigned to the training role.

The total requirement for Tan-SAM systems currently stands at 27 fire units for the JASDF and 47 fire units for the JGSDF, for which 1212 missiles will be procured. The last order for both services was placed under the FY88 defence budget requirements.

#### Description

The missile is of the single stage fire-and-forget type with four cruciform centrebody wings and four movable tail-mounted cruciform control fins. Propulsion is by a Nissan Motor solid-fuel rocket which exhausts an excessive amount of white smoke that both visually marks the launch site and allows an observant target to evade the oncoming weapon. The missile is also not kept in a controlled environment launch-container, which means it requires very careful and continuous maintenance practices for its sophisticated electronic components. The guidance system uses an autopilot



Close up of four-round missile launcher of Type 81 Tan-SAM low altitude surface-to-air missile system in travelling configuration (K Nogi)



Type 81 Tan-SAM low altitude surface-to-air missile launcher with missiles on upper arm only and stabilisers lowered (Kensuke Ebata)

for the first part of the flight and then switches to an infra-red (IR) passive homing seeker in the missile nose compartment.

Before launch, the scanning angle (in degrees) of the seeker head is pre-programmed by the FCS computer to avoid the missile tracking the sun. This data is calculated from the continuously updated information on the target position. The FCS also controls the launcher movements so that a round cannot be fired directly at the sun by accident.

Once the missile is in flight and has reached the point at which the seeker is activated, the IR head starts to scan the pre-programmed area of the sky to find the target. The guidance unit then locks on and the missile continues to follow the shortest course-to-intercept. At the target, either the HE-fragmentation warhead's contact or radar proximity fuze is activated to detonate the explosive. The lethal radius of the warhead is 5-15 m depending on the target type. No self-destruct circuit is fitted.

Although adverse weather conditions affect the missile performance, it is still said to be comparable to that of the Euromissile Roland under the same conditions. The intercept capabilities in cloud remain good. However, although no IR filters are fitted, targets employing IR decoy systems or manoeuvring within or near to the sun's disc as viewed from the missile stand a good chance of defeating its seeker by simply overwhelming it with spurious heat sources. Some protection is provided by the special electronic precautions incorporated into the design of the search pattern scanning programme (Intermediate Frequency - IF).

For operations against extremely low altitude targets in a heavy electronic jamming environment or against targets approaching from the rear of the launcher where the radar coverage is of marginal effect, control can be switched from the FCS vehicle to a tripod-mounted off-vehicle optical sight/control unit which is carried by each of the launchers. Once this is activated, the electronic link between the FCS and the launcher unit is automatically disengaged and the module is slaved to the sight.

At a fire unit position the personnel responsible for an engagement consists of the commander, radar operator and two launch operators. Each vehicle has to be levelled and stabilised by its hydraulically operated jacks and interconnected by electric cables and the field telephone/data link system. The normal distance between the FCS and the two launchers is around 300 m. The total time for these preparations is about 30 minutes.

Once these have been completed the surveillance radar on the FCS commences searching its assigned defence area. If only a single target is found, the engagement is relatively simple but for multiple targets priorities have to be assigned. When a designated target comes into effective range of the chosen missile on its launcher a visual signal is lit in the FCS and a weapon is launched using the guidance technique described.

The in-flight seeker lock-on feature allows a Tan-SAM fire unit to launch either two missiles simultaneously or successively while the first is still homing on to the target. Thus, theoretically, up to four targets can be engaged by a single fire unit. However, in practice this is doubtful as a single missile cannot be guaranteed a 100 per cent hit probability. The actual hit probability of a Tan-SAM missile is officially stated to be 75 per cent, even in cloud.

If required, the FCS module, the two launcher modules and their associated generators can be removed from their vehicles and used either for a fixed static site or as a helicopter-transported unit by JGSDF Kawasaki/Vertol V-107II-4/IIA-4 or Kawasaki/Vertol CH-47J Chinook for distances of up to 100 km and over. In either case a small dozer tractor is required to set up the launch site.

### Fire Control System (FCS)

The FCS module weighing approximately 3054 kg is mounted on the rear of a modified Isuzu Motors Ltd Type 73 (6 x 6) 3000 kg truck and consists of a 30 kW generator unit immediately aft of the driving cab with the system

control cabin to the rear. On top of the cabin roof is a 1 m wide, 1.2 m high 3D phased-array pulse Doppler radar antenna which is mechanically steered in azimuth and elevation. The vehicle is stabilised on site by three hydraulically operated outriggers. No armour or NBC protection is provided. The radar search range is around 30 000 m and an integral IFF interrogation facility is fitted. The antenna rotates at 10 rpm and sweeps 360° in azimuth and 15° in elevation during a full rotation. In a sector search it automatically sweeps 110° in azimuth and 20° in elevation. The system has a multi-target capability with each threat being assigned its own number by the FCS computer. The future position and elevation of an individual threat is calculated, then all the information on the various targets is displayed on the three CRT scopes below the antenna in the form of a target symbol, range, altitude and direction data. The unit commander assigns target priorities and indicates those which he intends to engage to the radar operator, who then moves a cursor onto each of the designated targets and presses a button to select it for precise tracking by the radar. Up to six targets can be tracked in this manner at any one time, each one being displayed on a CRT together with its continuously updated evaluation data. The launch data is fed into the selected weapon's onboard guidance system by the FCS computer which also directs the appropriate launcher to turn and elevate according to the position of the target. Once in range the missile is fired.

### Launcher

The launcher/generator system weighs approximately the same as the FCS and is mounted on the same type of truck chassis. It has no armour or NBC protection but has four hydraulically operated stabiliser jacks. The module is rectangular with two arms that have launcher rails on their upper and lower sides. On the front ends of each are two IR seeker covers which can be rotated through 180° to protect the missile heads during transit.

Each missile is loaded onto the launcher by hydraulically operated loading platforms mounted on each side of the vehicle. The missile, which arrives in a simple box-like container, is manually picked up and placed on the loading platform by the fire unit's crew after removing the container's cover. The loader hydraulically lifts the round into the loading position where the aft end of the launcher rail is slid back to reveal two latches which are then inserted into a slit on the missile body to hold it in place. The rail is moved back to its original position which automatically advances the round into the launch position. This process is repeated four times until all four launch rails are loaded. The total time taken for this action is approximately three minutes.



Fire control system of Type 81 Tan-SAM low altitude surface-to-air missile in travelling configuration (Kensuke Ebata)



## Variants

## Type 81 Tan-SAM Kai Low Altitude Surface-to-air Missile System

In early 1981 the Japanese Defence Agency awarded a Yen 3.14 billion contract to Toshiba for initial research and development work on an improved Tan-SAM Kai (Kai being a Kaizo or modification symbol) missile. This incorporates a strap-down active radar homing seeker, intermittent direction command/programme guidance and mid-course lock-on after launch capabilities into the weapon.

The improvements are to enhance the missile's current areas of weakness; namely its range, hit probability and ECCM performance.

## SPECIFICATIONS (missile)

TYPE	single stage, low altitude
LENGTH	2.7 m
DIAMETER	0.16 m
WING SPAN	0.60 m
LAUNCH WEIGHT	100 kg
PROPULSION	solid fuel sustainer rocket motor
GUIDANCE	pre-programmed autopilot with passive IR terminal homing
WARHEAD	HE-fragmentation with contact and radar proximity fuzes
MAX SPEED	Mach 2.4
MAX EFFECTIVE RANGE	7000 m
MIN EFFECTIVE RANGE	about 500 m
MAX EFFECTIVE ALTITUDE	around 3000 m
MIN EFFECTIVE ALTITUDE	15 m
LAUNCHER	trainable four-round static or vehicle-mounted module

**Status:** Production complete. In service with the Japanese Ground Self-Defence Force and Japanese Air Self-Defence Force.



*Fire control system of the Type 81 Tan-SAM low altitude surface-to-air missile in operational configuration and stabilisers deployed (Kensuke Ebata)*

**Manufacturer:** Prime contractor and system integration: Toshiba (Tokyo Shibaura Electric) Company Limited, 1-6 Uchisaiwacho, 1-Chrone, Chiyoda-ku, Tokyo 100, Japan.

**Main subcontractors:** Vehicles: Isuzu Motors Limited, 22-10 Minami-oi, 6-Chrone, Shinagawa-ku, Tokyo, Japan.

Rocket motor: Nissan Motor Company Limited, Aerospace Division, 5-1 3-Chrome, Momoi, Suginami-ku, Tokyo, Japan.

## NORWAY

## Norwegian Adapted HAWK (NOAH) Low to Medium Altitude Surface-to-air Missile System

## Development

In mid-1983 the Royal Norwegian Air Force completed a study on its future air defence requirements. The plan the team drew up involved an incremental improvement programme which was to be phased over a number of years.

The first part of the plan concerned improving the response capabilities of a proven surface-to-air missile system, the I-HAWK (qv USA entry in this section), whilst considerably reducing the maintenance and manpower requirements of the basic Fire Unit associated with it.

A competition for the development of what became known as the NOAH surface-to-air missile system was held during the latter part of 1983 and awarded to HKV, a joint venture company formed by Hughes Aircraft Company Ground Systems Group and NFT (Norsk Forvarsteknologi A.S), in January 1984.

A total of six NOAH battery sets were ordered in February 1984 for airfield defence at Bodo, Andøya, Bardufoss, Evenes, Ørland and Vårnes. The first battery was deployed during early 1987, in Triad configuration to provide both effective radar coverage and an enhanced electronic counter-countermeasures capability by using such techniques as Jam Strobe triangulation. All six batteries were operational by mid-1989.

The approach HKV adopted for the NOAH battery Fire Unit configuration was two-fold:

- (1) replacement of the long-range AN/MPQ-50 Pulse Acquisition Radar, the low altitude AN/MPQ-48 Improved CW Acquisition Radar and the AN/MPQ-51 Range-only Radar by a single electronically scanned 3D Hughes TPQ-36A Low Altitude Surveillance Radar (LASR) set.
- (2) replacement of the Information Co-ordination Central, AN/TSW-8 Battery Control Centre and AN/MSW-11 Improved Platoon Command Post by a single NFT-developed shelter Fire Distribution Centre (FDC).

The AN/MPQ-46 High Power Illuminator radar, the three M192 launcher assemblies and the MIM-23B I-HAWK missiles remain untouched.

The TPQ-36A radar and the FDC together form what is known as the Acquisition Radar and Control System (ARCS). A total of 25 ARCS have been procured, 18 for the NOAH programme, one as Institutional trainer and six for use as tactical radar centres providing target data for Air Force 40 mm Bofors L/70 anti-aircraft guns and then Bofors RBS 70 manportable SAM systems as the guns are replaced in the early 1990s.

In a netted NOAH battery one FDC is designated as the senior Fire Unit managing both its own local NOAH elements and communicating with the

air defence upper echelons. Any of the FDCs can undertake this role or be subordinate to the senior Fire Unit.

Other ARCS-controlled air defence assets such as gun or manportable SAM systems can also be included in the overall integrated ARCS communications network to create a layered air defence system that complicates and defeats enemy tactics and countermeasures.

## Description

The AN/MPQ-46 High Power Illuminator radar, M192 launcher and MIM-23B I-HAWK missile are fully described elsewhere in this section. The remaining components of the NOAH ground equipment are as follows:



*Interior of NFT Fire Distribution Centre (FDD) which is manned by two operators at a KMC 9000 console using KS 500/KS 800 computers. With dual controls, all functions are either duplicated or transferable between the operator positions*



NFT Fire Distribution Centre (FDC) which is used with both the NASAMS and NOAH surface-to-air missile programmes



Norwegian HAWK SAM being launched (left) with Hughes TPQ-36A radar on right which has an instrumented range of up to 75 km

#### Acquisition Radar and Control System (ARCS)

The ARCS unit provides the target surveillance, target identification, threat evaluation and weapon assignment information for the NOAH Fire Unit.

The 3D highly mobile trailer-mounted I/J-band range gated Doppler frequency TPQ-36A is a computer-controlled low altitude radar system designed to detect targets infiltrating beneath the coverage provided by long- and medium-range air defence radar sensors. It uses independent  $2^\circ \times 1.7^\circ$  search, verify (by a  $5.5^\circ$  electronic backscan separation from the search beam) and track pencil beams with a phase beam scanning antenna to provide the target range, bearing and elevation cueing data to the FDC.

The radar antenna rotates mechanically in azimuth to provide a full  $360^\circ$  coverage with a  $20^\circ$  selectable elevation coverage between limits of  $-10$  to  $+55^\circ$ . It can track up to 60 plus targets at ranges up to 75 km and is fitted with an integral Mk XII IFF subsystem. Acquisition range on a low radar target cross-section fighter-sized target is said to be 40 km.

The scan data update rate is once every two seconds (that is, an antenna rotation rate of 30 rpm). Target Doppler signal processing is used to reject clutter caused by natural land, sea and rain returns as well as chaff ECM.

Elevation coverage has been successfully demonstrated on fixed- and rotary-wing targets operating effectively at velocities of 0 to 724 km/h at altitudes from ground level up to 1800 m.

The radar can also perform both automatic jammer tracking and sector search in elevation and azimuth and has the ability to conduct jammer burn-through against ECM systems.

The associated FDC box-shelter is carried on the rear of a  $4 \times 4$  flat bed lorry chassis and can be off-loaded to the ground by means of four hydraulic jacks mounted on each corner of the shelter.

Inside are communications equipment and a two position multi-function KMC9000 colour display console with keyboards and touch panels that are coupled to KS 500/KS 800 computers.

For NOAH the FDC positions are for a Tactical Control Officer (TCO) who assesses and manages the overall Fire Unit air defence battle and a Fire Control Officer (FCO) who engages the targets with the Fire Unit elements and controls the integrated passive Norwegian Tracking Adjunct System (NTAS).

The FDC receives and integrates the target data from its own TPQ-36A radar and if netted, as the senior FDC, from at least two other sensors to

provide a complete tactical air picture of the battery's protection zone to afford all the FDCs in the net both early warning and enhanced battle control management data in the form of continuous track information on targets despite terrain following and evasive manoeuvres and shared system status display.

FDC operation can be either manual, semi-automatic or fully automatic. It automatically performs the threat evaluation task and indicates the optimum weapon assignment per target for the Fire Unit and, if it is the senior FDC, by considering all the other HAWK and air defence assets such as guns or manportable SAMs netted in the system assigned to the protection zone.

#### Norwegian Tracking Adjunct System (NTAS)

This is an integrated passive day/night infra-red sensor unit mounted above and between the two AN-MPQ-46 High Power Illuminator radar dishes. Fitted at the rear of the radar dishes are the NTAS power supply and system electronics boxes.

The unit is designed for use either when the illuminator radar is silent or in a heavy ECM environment when it is being jammed to provide accurate raid-size assessment, hostile-act verification, passive tracking, kill assessment and enhanced system operation functions.

The acquisition and tracking range is in excess of 20 km and all the system controls, including the joystick, main and auxiliary control panels and visual display, are located in the FDC at the FCO console position.

**Status:** Production as required. In service with the Royal Norwegian Air Force (six batteries).

**Manufacturers:** Enquiries to HKV, 1325 Airmotive Way, Suite 175-N, Reno, Nevada 85902, USA.  
Telex: 685504/910 5921 246

Norsk Forsvarsteknologi A/S, N-36000 Kongsberg, Norway.

Hughes Aircraft Company, Ground Systems Group, 1901 Malvern Street, PO Box 3310, Fullerton, California 92634, USA.  
Telephone: (714) 732 32 32  
Telex: 910 3486 290

## Norwegian Advanced Surface-to-air Missile System (NASAMS) for Low to Medium Altitude Surface-to-air Missile System

#### Development

In January 1989 the Royal Norwegian Air Force (RNoAF) awarded the Phase 1 study contract to a joint venture company formed by Norsk Forsvarsteknologi (NFT, formerly Kongsberg Våpenfabrik) and Hughes Aircraft Company.

The contract provides for the development of a short- to medium-range semi-mobile ground-launched version of the Hughes Aircraft Company Missile Group AIM-120A Advanced Medium-Range Air-to-Air Missile (AMRAAM) under the designation NASAMS, two batteries of which will be initially fielded to replace the four obsolete Nike Hercules SAM batteries

currently, deployed in south-east Norway to defend the Gardemoen and Rygge air bases near Oslo. Two of the Nike Hercules batteries were disbanded by the end of 1989 and the other two are due to go in 1992.

Ultimately, it is envisaged that by the end of the 1990s all six of the Norwegian Adapted HAWK (NOAH) batteries currently in service will also have been upgraded to the NASAMS configuration, which includes the Hughes TPQ-36A (of which 24 are currently in Norwegian service for use with the NOAH batteries) and the Fire Distribution Centre (FDC, of which NFT has produced 25 for the NOAH batteries).

The development team defined the configuration of the launcher and conducted two unguided test launches of AMRAAM ballistic test rounds to evaluate the weapon's initial launch characteristics during the first 0.5 second of flight before the full aerodynamic control is effected. The launches were successfully carried out in October and November 1989 at Point Mugu, California.





Sequence of photographs showing a Hughes Aircraft Company AMRAAM during the first ground-launch of the missile in late 1989

Phase 2 full-scale development of the system is currently underway and involves four launches of guided rounds at a US missile range to evaluate the complete integrated system.

Phase 3 is the production stage with the six year programme due to culminate in the delivery to the RNoAF of an initial 18 launchers and 108 missiles for the first two batteries.

#### Description

A NASAMS Fire Unit (FU) consists of three truck mobile six-round launcher platform subsystems, an FDC and a 3D TPQ-36A radar. The FU composition allows for up to 60 targets to be handled independently.

Up to four fire units can be linked together in a command network to form the battery, so that if required, any of the three radars can provide targeting data to any of the 9 to 27 available launcher platforms.

The gimballed missile launcher is pallet-mounted on a truck and off-loaded at a launch site where it is levelled by adjusting a hydraulic lifting system. The missile pallet is raised to point the missile at the fixed launch angle and slewed in azimuth to the desired launch bearing.

The six missiles are attached to standard LAU-129 aircraft launcher rails and protected by canisters with weather covers. The missiles are standard solid-state AIM-120A all-weather all-aspect air-to-air rounds which use a Nortronics strap-down inertial guidance unit for the initial flight phase and a Hughes I/J-band active radar all-aspects lookdown seeker for terminal homing. It also has a home-on-jam capability. Flight control is by cruciform rear fins. The HE blast-fragmentation warhead and fuze are activated in the final approach to the target and are detonated either by the proximity delay or contact fuzing circuits.

In operation the missiles will be maintained in an unpowered condition until a firing command is initiated for the selected weapon at the FDC. Once this is received at the launcher, the missile start sequence is activated and boost motor ignition starts the launch 1.4 seconds later.

Initial position data is fed into the AIM-120A inertial guidance unit prior to launch by an indigenously designed and built navigation system mounted on the launcher. This guides the weapon towards the predicted target location during the early part of the flight trajectory.

Upon approaching the location the active seeker is switched on in a high pulse repetition frequency (PRF) mode to acquire and track the target. The missile then changes to its medium PRF mode for the terminal acquisition and track attack phase.

The TPQ-36A low altitude I/J-band range gated pulse Doppler frequency agile search and track radar uses a  $2^\circ \times 1.7^\circ$  3D pencil beam and phase beam scanning antenna to provide accurate target range, bearing and elevation track data to the manned field mobile FDC shelter. The radar antenna rotates mechanically in azimuth to provide  $360^\circ$  coverage with an elevation coverage between limits of  $-10^\circ$  to  $+55^\circ$ . Beam scheduling is computer-controlled and adaptive to mission requirements. Elevation coverage has been successfully demonstrated between 3 and 12 000 m on fixed- and rotary-wing aircraft operating from the hover to 724 km/h. It can track up to 60 plus targets at ranges up to 75 km and is fitted with an integral Mk XII IFF subsystem. Acquisition range on a low radar cross-section fighter sized target is said to be 40 km. The system has a two second (30 rpm) update rate.

The FDC contains a command/control processor and display subsystem, a digital radar signal processor and a radar control computer.

Although having a shorter engagement range than the NOAH systems, the NASAMS battery more than compensates for this by having an autonomous launch-and-leave capability allowing engagements which could have up to 54 independently targeted AMRAAMs in the air at any one time from a fire unit.

Also, as NASAMS utilises a distributed architecture that does not require launchers/missiles to be collocated with the rest of the system then, as the launchers can be placed up to 25 km away, this has the effect of actually providing a larger area coverage.

These factors, plus the weapon's relatively short reaction time, considerably increases the enemy's perceived problems in trying to overwhelm the RNoAF air defence network. The system also has an up and over trajectory capability to engage very low flying targets behind rough terrain features.

#### MISSILE SPECIFICATIONS (provisional)

TYPE	single stage low to medium altitude
LENGTH	3.655 m
DIAMETER	0.178 m
MAX SPAN	0.64 m
LAUNCH WEIGHT	156 kg
PROPULSION	single stage solid propellant rocket motor
GUIDANCE	inertial mid-course with active radar terminal homing
WARHEAD	20.4 kg HE-fragmentation with proximity and contact fuzing
MAX SPEED	Mach 2-3
LAUNCHER TYPE	6-rail trainable pallet system

**Status:** Development. On order for the Royal Norwegian Air Force (2 batteries).

**Manufacturers:** Enquiries to HKV, 1325 Airmotive Way, Suite 175-N, Reno, Nevada 85902, USA.

Telex: 685504/910 5921 246

Fire Direction Centre: Norsk Forsvarsteknologi A/S, N-36000 Kongsberg, Norway.

System design and radar: Hughes Aircraft Company, Ground Systems Group, 1901 West Malvern Street, PO Box 3310, Fullerton, California 9266, USA.

Telephone: (714) 732 32 32

Telex: 910 3486 290

AIM-120 Missile: Hughes Aircraft Company, Missile Systems Group, 8433 Fallbrook Avenue, Canoga Park, California 91304, USA.

Telephone: (213) 888 2400

Telex: 910 4944 997

## SWEDEN

## Swedish Ordnance BAMSE Medium-Range Surface-to-air Missile System

### Development/Description

Late in 1991, Swedish Ordnance delivered to the Swedish Defence Material Administration (FMV), their project definition study for the new BAMSE MSAM (Medium-range Surface-to-Air Missile).

The \$15 million project definition contract was awarded in 1989 and a decision is expected to be made sometime in 1992 as whether to move into the full scale development (FSD) stage.

At present the Swedish Army has no air defence system to cover the gap between the Swedish Ordnance RBS-70, and the soon to be introduced RBS-90, and the Raytheon Improved HAWK SAM which is only deployed in small numbers.

If Swedish Ordnance get the go-ahead next year then it is expected to take six years to develop and test BAMSE, one year to prepare for production with volume production commencing around the year 2000.

The rationale behind the development of BAMSE is the changing threat scenario. Attacking aircraft can now release their weapons at much greater distances from the target so they will be out of range of most existing air defence weapon systems.

In addition, aircraft have a greater capability of conducting operations in bad weather and at night with attacking forces also having a significant increase in jamming capability.



Key requirements of the Swedish Army include an ease of employment in all types of terrain, effective against all types of target beyond the year 2000, ranging from small missiles to large transport aircraft, all weather capability, greater coverage than existing Swedish Army low level air defence systems, range and altitude coverage in excess of 10 km, good self-defence capability and be highly resistant to jamming.

A typical BAMSE battery would consist of a Combat Control Unit (CCU) and two connected firing units, or Fire Control Unit (FCU).

The truck-mounted CCU uses a modified Ericsson PS90 Giraffe radar which is mounted on top of an arm that can be raised to a height of 12 m to give it greater surveillance capability.

Improvements to the PS90 radar would include longer range, greater altitude coverage, improved resistance to jamming, improved signal processing, and the 3D radar will measure the altitude of the target.

The PS90 will carry out automatic tracking and threat evaluation and as with earlier Giraffe radars it can also be used to control other types of air defence systems.

The FCU is connected to the CCUs by cable or radio and the distance from the two units can typically be 10 km. The radio system to be used would be the Swedish Army's new field radio 8000 which is claimed to be highly resistant to jamming.

Although typically two FCUs are coupled to one CCU, up to four FCUs can be connected if required by the tactical situation.

The trailer-mounted FCU contains all of the elements for the engagement of a target and is towed by a cross-country vehicle that also carries additional missiles for manual reloading. On arrival at the firing position the FCU can be quickly deployed.

The FCU has four missiles in the ready to fire position, two either side of the fully enclosed environmentally controlled cabin and mounted on the roof is an elevatable mast which contains the fire control radar, two TV cameras and IFF sensors. The FCU has its own built in generator and navigation unit.

The missile is guided in flight by the fire control radar which is a further development of the Ka-band Ericsson Eagle radar. As the fire control radar is mounted on a mast it has increased capabilities to track, acquire and track low flying targets. Typically the CCU would first acquire and track the target and then hand over to the FCU to actually carry out the target engagement.

The fire control radar provides target information to the two man crew and gives the maximum possible amount of information to enable them to successfully engage the target. Target engagement system is automatic command-to-line-of-sight.

To shorten reaction and flight time, BAMSE will utilise a new two-stage (launch and sustainer) high velocity missile fitted with a proximity and impact fuze.

According to Swedish Ordnance, its pre-fragmented warhead will be capable of defeating a wide range of targets including missiles, RPVs and aircraft. The missile will be very manoeuvrable throughout its flight envelope.

BAMSE will have built-in test equipment (BITE) and integrated simulators to enable training to be carried out on the actual system without firing any real missiles.

BAMSE will be able to provide protection for air bases and other strategic installations such as population centres, as well as mobile units, under all-weather conditions. It will be fully air-portable in a Lockheed Hercules C-130 transport aircraft which is currently in service with the Royal Swedish Air Force.

**Status:** Project definition stage completed late in 1991 (see text).

**Manufacturer:** Swedish Ordnance (previously AB Bofors), S-69180 Bofors, Sweden.

Telephone: (0) 586/8100

Telex: 732 10 bofors

Fax: (0) 586 58145

*Full scale mock-up of the Swedish Ordnance BAMSE Medium-range Surface-to-Air Missile (MSAM) deployed in a typical firing position with the Fire Control Unit with four missiles in the ready to launch position*

## Swedish Ordnance RBS 90 Low Altitude Surface-to-air Missile System

### Development

To complete the RBS 70 family (qv entry in *Manportable SAM Systems* section) Bofors (now Swedish Ordnance) was awarded a development

contract in 1983 by the Swedish Defence Procurement Administration (FMV) for the RBS 70M (M=Mörker, Swedish for night) day/night missile system. Contracts were also placed with Ericsson Radar Electronics AB for complementary search and tracking radars and a thermal imaging video camera system for the weapon and to Hägglund Vehicles AB for the conversion of its Bv 206 articulated tracked vehicles as the fire units.

First production systems were delivered to the Swedish Army late in



1991 with first unit expected to become fully operational in 1993. The RBS 90 system is due to supplement rather than replace the RBS 70 and will be deployed at the divisional level in battalion units of three companies. These will comprise a central Surveillance-Command, Control and Communications combat control platoon with an Ericsson PS-90 (Giraffe 75) G-band radar vehicle carrying a 13 m high antenna mast and four to six fire units.

The frequency-agile radar has a 75 km range/12 500 m altitude capability and is able to automatically detect/track up to 20 targets simultaneously due to its Moving Target Indicator (MTI) and automatic hovering helicopter detection capabilities.

The divisional companies may be detached as required to defend either field forces or high value targets such as airbases. The RBS 90 is compatible with existing Mk 1 rounds but will be deployed with the Mk 2 missile.

#### Description

The basis of the fire unit is two Bv 206 tracked vehicles:

**Fire Control Vehicle** - carries two men in its tractor unit with a generator and the system's radio communication system which accepts data transmission from the PS-90 central surveillance radar (this can also be performed by cable). The trailer unit carries another three crew (the fire controller, who doubles as the system's radar operator, the engagement co-ordinator and the gunner), the system electronics, reload missiles in their container-launcher tubes, the operator's weapon and radar simulator and a roof-mounted Ericsson PS-91 H/I-band low probability of intercept 8-10 km hovering helicopter, 16-20 km fixed-wing aircraft range 7000 m altitude capability radar (a derivative of the 3D pulse Doppler Helicopter and Airplane Radar Detection (HARD) search and acquisition radar set) with integrated IFF.

This radar provides aircraft bearing, elevation and range for the fire controller to select targets for engagement from up to eight being tracked. The information provided is sufficiently accurate for the target to be acquired by the launcher's own tracking sensors. In poor visibility a target can be tracked by radar until it becomes visible through these optronics.

The radar does not normally transmit when a number of RBS 90 fire units are co-ordinated by a central surveillance radar but functions basically as the RBS 70 with target assignment. The radar is a backup if more accurate target data is required or when the fire unit is acting autonomously.

The gunner himself is seated in front of a video TV screen which includes outputs from either the thermal imager or daylight TV camera tracking devices on the remotely controlled, power-operated RBS 90 twin tube launcher stand. All the gunner has to do is keep his sight cross-hairs aiming mark on the designated target handed over to him by the fire controller. The sight on the launcher is servo-controlled from the fire unit.

**Transport Vehicle** - The tractor unit carries five crew whilst its trailer unit carries the power converter device, the system sight, the dismantled launcher stand assembly, missile container launcher tubes, hoist, cooling power supply, ground support equipment and extra vehicle fuel containers.

The boresighted laser guidance unit remains with the launcher stand which weighs 185 kg complete when assembled and can either be deployed on the ground, as with the RBS 70 system, or mounted in or on another vehicle such as a third Bv 206. Deployment time for the ground role engagement is less than five minutes.

**Status:** Production. Entering service with the Swedish Army.

**Manufacturers:** RBS 90, RBS 90 system integration, Rb 70 Mk 2 missile Swedish Ordnance, S-691 80 Bofors, Sweden.

Telephone: (46) 586 8100

Telex: 732 10 bofors

Fax: (46) 586 58145

PS-90 Giraffe 75 and PS-91 radars

Ericsson Radar Electronics AB, Surface Sensors Division, S-431 84 Mölndal, Sweden.

Telephone: (46) 31 671000

Telex: 20905 ericras

Fax: (46) 31 873891

BV 206 vehicle

Hägglund Vehicles AB.

S-891 82 Örnsköldsvik, Sweden.

Telephone: (46) 0660 800 00

Telex: 6051

Fax: (46) 0600 826 49



Swedish Ordnance RBS 90 low altitude surface-to-air missile system deployed in the field



Ericsson HARD 3D radar system on Bv 206 all-terrain vehicle

## TAIWAN

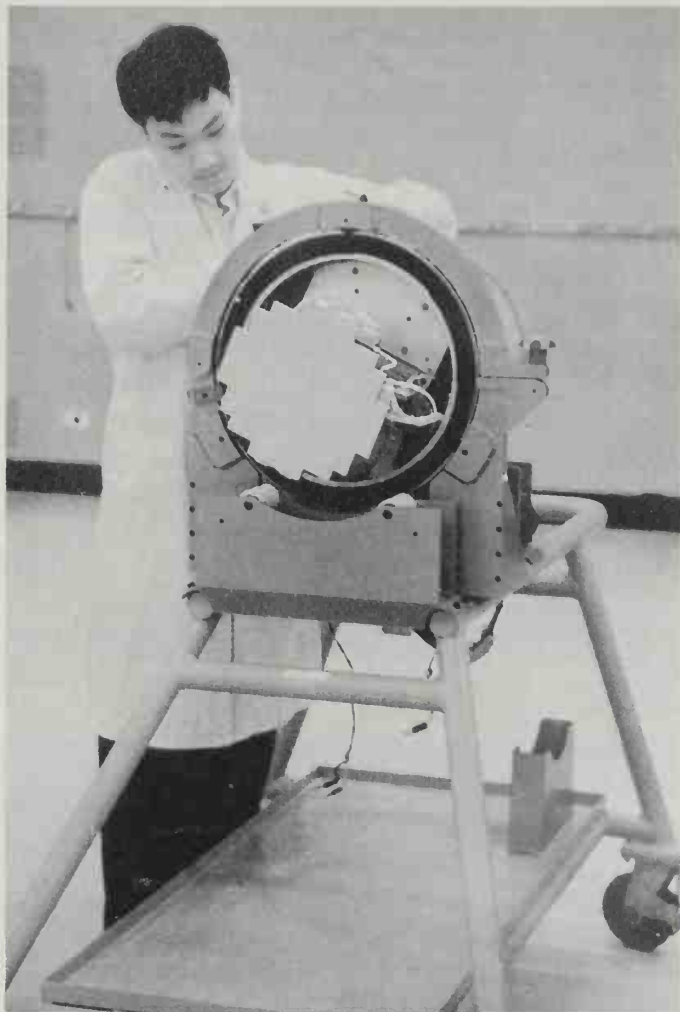
### Tien Kung I Low to Medium Altitude Surface-to-air Missile System

#### Development

In the mid to late 1970s the Sun-Yat-sen (or Chung Shan) Institute of Science and Technology began work on a new surface-to-air missile system for the Taiwanese Army proposed 1990s Sky Net air defence system network that was based on the I-HAWK missile. A higher thrust rocket motor was to be installed to increase both the speed and maximum engagement altitude. The airframe and control surfaces were to be redesigned to cope with the higher velocities and to increase the weapon's manoeuvring capabilities and a new guidance system was fitted. This combined mid-course command guidance with a terminal Semi-Active

Radar (SAR) seeker head which allowed the missile to fly an energy-efficient flight path to the vicinity of the target where the seeker head would take over for the final attack. The theory was that the actual radar illumination of the target to produce the reflected electromagnetic energy signals for the seeker to home on would be initiated only during the last seconds of the engagement to give the target the minimum amount of time either to evade or commence ECM. Ultimately this project produced a missile design that resembled a scaled-up Hughes AIM-54 Phoenix.

However, due to the acquisition of more sophisticated missile technology in the form of an 85 per cent transfer from Raytheon and the US Government of the MIM-104 Patriot design, the Chung Shan Institute was directed to stop work on the above and, in 1981, start development of the Tien Kung I (Sky Bow I) missile system based on the Patriot. Various combinations of different components and aerodynamic configurations to suit local production



*TK-1 semi-active radar homing seeker (DTM)*



*CS/MPG-25 CW illumination radar used with the Tien Kung I SAM system (DTM)*



*Tien Kung I SAM quad-box launcher (DTM)*



*Tien Kung I SAM being launched (DTM)*

needs were tried, using computer-aided design techniques coupled with an exhaustive scale model wind tunnel test programme and, in the final stages of the work, full-scale test firings that included one missile configuration fitted with much larger tail surfaces than Patriot. Firing trials were completed in March 1985.

#### **Description**

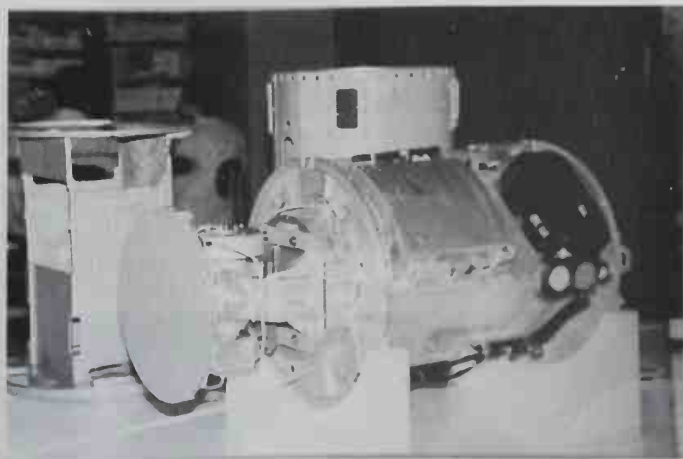
In the end, however, the Tien Kung I's physical appearance and basic operational parameters remained essentially similar to those of Patriot (see entry in this section). For the target acquisition, tracking and mid-course missile guidance requirements the army has deployed the CSIST/GE ADAR-1 semi trailer-mounted 500 km range Chang Bei (Long White) multi-function phased-array radar with associated fire control computer system

and the CS/MPG-25 continuous wave dish antenna illuminator radar that are tied into the main phased-array radar on a similar time-share basis to that employed by the US Navy's shipborne RCA AEGIS air defence system in order to allow multiple target engagement capability.

Each Tien Kung I battery (Fire Unit) is said to have one Chang Bei and two CS/MPG-25 illuminator radars which each have three or four 4-round missile launchers attached.

The Chang Bei radar was developed by the Chung Shan Institute with technological assistance from General Electric Company's RCA Electronic Systems department.





*Tien Kung I active radar seeker currently under development (DTM)*

The CS/MPG-25 is a solely Chung Shan Institute development and was derived from the I-HAWK AN/MPQ-46 HPI radar but is estimated to be something like 60 per cent more powerful in output. Improved EW, ECM and IFF capabilities were also introduced.

Prior to these Chung Shan Institute developments, operational Tien Kung I batteries were fitted with interface electronics to operate with the fire control radars of I-HAWK batteries. Post deployment of the radars, the Tien He (interface) system was introduced for both systems to co-ordinate their actions during an engagement.

There is no Track-Via-Missile (TVM) homing capability as this technology was not included as part of the package released to Taiwan. Despite this, the basic SAR seeker-equipped version is being supplemented in service by a variant fitted with a passive all-aspects liquid nitrogen cooled infra-red indium actinide seeker. This provides the battery with the option of firing more than one missile type during a single or multiple target engagement. This variant was tested successfully in April 1985 against a HAWK missile target.

The trailer-mounted launcher station is almost identical to that used for Patriot except in minor details such as the frangible covers on the four container-launcher boxes.

#### SPECIFICATIONS (provisional)

TYPE	single stage low to medium altitude
LENGTH	5.3 m
DIAMETER	0.41 m
WEIGHT	approx 900 kg
WARHEAD	est 90 kg HE-fragmentation with proximity and contact fuzing
GUIDANCE	inertial with command updates and semi-active radar, active radar or passive IR homing seeker options
PROPULSION	single stage solid propellant sustainer/booster rocket motor
MAX SPEED	est Mach 3.5
RANGE	60 000 m plus
LAUNCHER	mobile trainable 4-round semi-trailer

**Status:** In production. In service with the Taiwanese Army.

## Tien Kung II Medium to High Altitude Surface-to-air Missile System

### Development/Description

Using the technology and experience gained from its previous surface-to-air missile development projects, the Chung Shan Institute of Science and Technology developed a replacement for the Taiwanese Army's MIM-14 Nike Hercules systems. Known as Tien Kung II (Sky Bow II), the first test firings apparently took place in the mid-1980s with operational deployment occurring in September 1989.

The Tien Kung II is essentially the Tien Kung I round equipped with a second-stage solid propellant rocket booster motor section.

Two launch systems are used: a modified Nike Hercules single-rail ramp and underground clusters of vertical launch systems.

### Variants

#### Tien Kung III

This is a ramjet powered weapon with third-stage external boosters to produce the speed necessary for efficient ramjet operation.



*Tien Kung II missiles being carried on 4 x 2 trucks for display purposes. The missile is reputed to have a top speed of Mach 4.5 (DTM)*



*Tien Kung II vertical box launcher mounted on a Nike Hercules launch ramp (DTM)*

**SPECIFICATIONS** (provisional)

TYPE	two-stage medium to high altitude
LENGTH	9.1 m
DIAMETER	
first stage	0.41 m
second stage	0.57 m
WEIGHT	approx 1100 kg
WARHEAD	est 90 kg HE-fragmentation with proximity and contact fuzing
GUIDANCE	inertial with command updates and semi-active radar, active radar or passive IR homing seeker options

**PROPULSION**

MAX SPEED  
RANGE  
LAUNCHER

solid propellant rocket booster and solid propellant rocket motor sustainer  
Mach 4.5  
100 000 m plus  
monorail or vertical launch silo system

**Status:** Tien Kung II - production. In service with Taiwanese Army. Tien Kung III - development phase.



*Vertical test launch on Tien Kung II SAM (ROC DND)*



*Underground launcher for Tien Kung II SAM system (DTM)*

## Sky Sword I Low Altitude Surface-to-air Missile System

**Development**

In mid-1988 the Taiwanese Cabinet, in its report to the Taiwanese Legislature, revealed that the Ministry of National Defence had successfully undertaken modification of the Chung San Institute of Technology Sky Sword I infra-red passive homing air-to-air missile for mobile, naval and static ground launch applications.

It is envisaged that the Sky Sword I will eventually replace the MIM-72 Chaparral/Sea Chaparral weapons.

**Description**

The all-aspects Sky Sword I is similar in physical appearance to the AIM-9G/H Sidewinder. Flight control is by cruciform canard fins. Maximum range is estimated to be 9000 m within altitude limits of 15 to 6000 m.

**SPECIFICATIONS** (missile - provisional)

TYPE	single stage low altitude
LENGTH	2.87 m
DIAMETER	0.127 m
MAX SPAN	0.64 m
LAUNCH WEIGHT	90 kg
PROPULSION	solid fuel rocket motor
GUIDANCE	passive infra-red homing
MAX SPEED	Mach 1 plus
MAX RANGE	9000 m
MAX ALTITUDE	6000 m
MIN ALTITUDE	15 m
LAUNCHER	4-round trainable static (or mobile)

**Status:** Entering production. On order for the Taiwanese Army and Air Force.



## UNION OF SOVIET SOCIALIST REPUBLICS

### SA-1 'Guild' Medium Altitude Surface-to-air Missile System

#### Development

Development of the R-113 (NATO designation SA-1 'Guild') guided air defence missile system was begun in 1950 by the Lavochkin OKB design bureau with the first trial launches in 1951. By 1952 the initial trial units were formed in the Moscow PVO-Strany (*Voyska Protivovozdushnoy Oborony Strany* — Troops of the National Air Defence) district. Between 1954 and 1958, their strength was increased to several Air Defence Force Armies, each of several Corps (with three-four Divisions apiece) and independent Brigades and Regiments totalling some 3200 launchers in battalions of six static launcher rails.

Each site was constructed in a characteristic herring-bone pattern. So many were built round the Moscow area, in three concentric circles, that the Soviet Union had to build the two outer Moscow ring roads to support them.

The SA-1 missile was first shown in public during the 7 November 1960 Red Square Parade in Moscow and has remained in continuous front line service until 1980 when the numbers began to decline due to the introduction of SA-10 (S-300) weapons. In 1988 only 1600 launchers were still active. The previous year it was 1860.

The SA-1 'Guild' was used on a number of occasions during the late-1950s against CIA-flown high altitude overflights of the Soviet Union by Lockheed U-2s without success.

#### Description

The R-113 (SA-1) is a longer and more streamlined version of the R-101E surface-to-air missile which was a Soviet copy of the Second World War German Wasserfall design. It is a single stage weapon which uses an Isayev storable liquid fuel rocket motor with a turbo-pump fuel feed system. Steering is by four canard fins on the nose.

During its service life the weapon has undergone a number of internal improvements to increase its reliability. Externally the two major variants fielded are distinguished by the use of a small protective covering over the rocket exhaust on the final type. The maximum slant range is about 40 km and the maximum engagement altitude is around 20 000 m. The single rail launcher is semi-fixed and lifts the missile into the vertical for firing.

Initial target detection is usually carried out by the elderly A-band medium to high altitude (up to 45 720 m) P-14 (NATO designation Tall King) 600 km

range fixed site peripheral early warning radars which hand the contact over to the 300 km range E/F-band target acquisition radar of the R-113 system known by the NATO designation Gage. This is usually used in conjunction with a van-mounted E-band nodding heightfinder radar such as the 200 km range, 30 000 m altitude capability PRV-9 (NATO designation Patty Cake) set to gain additional target data before the central guidance radar of the R-113 battalion is locked on. Known by the NATO designation Yo-Yo, this 150 km E/F-band radar is unique in having six antennas, each rotating about  $70 \times 70^\circ$ . Using 'flapping' beams it can track up to 30 targets simultaneously and guide two to three missiles at any one time at a single target.

For the whole flight, the R-113 is command guided with the 250 kg HE-fragmentation warhead detonated either by its proximity fuze or a command signal. Its manoeuvring capabilities at the upper part of its flight envelope are considerably limited by its low fuel supply and small control surfaces.

#### SPECIFICATIONS (missile)

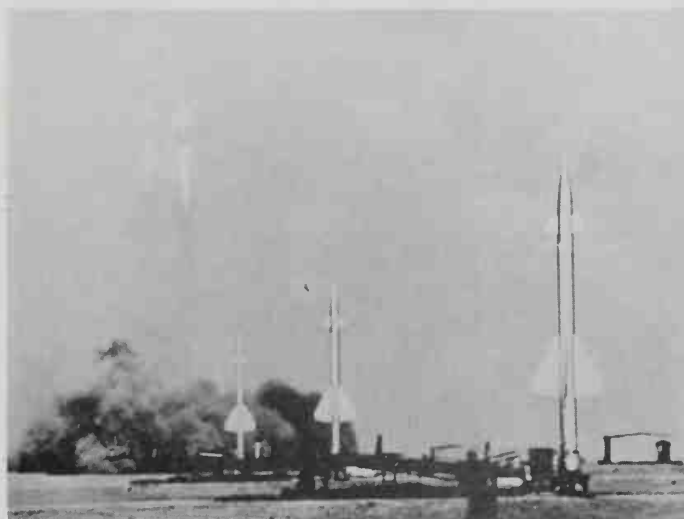
TYPE	single stage, medium altitude
LENGTH	12 m
DIAMETER	0.7 m
MAX SPAN	2.7 m
LAUNCH WEIGHT	3500 kg
PROPULSION	storable liquid fuel rocket motor
GUIDANCE	command
WARHEAD	250 kg HE-fragmentation with proximity and command fuzing
MAX SPEED	Mach 2.5+
MAX RANGE	40 km
MAX ALTITUDE	20 000 m
MIN ALTITUDE	4000 m
LAUNCHER	single rail semi-fixed vertical

**Status:** Production complete. In service only with the Soviet Union (being retired).

**Manufacturer:** Soviet state factories. Designed by Lavochkin OKB design bureau.



Final version SA-1 'Guild' surface-to-air missiles on semi-trailers being towed by ZIL-137 (6 x 6) tractor trucks through Red Square, Moscow, in November 1982



SA-1 'Guild' surface-to-air missiles being launched from their single rail launchers

### SA-2 'Guideline' Medium to High Altitude Surface-to-air Missile System

#### Development

Development of the V-75 Dvina (Soviet river name, NATO designation SA-2 'Guideline') system began during 1953 at the Lavochkin OKB design bureau as a medium to high altitude SAM system for use against non-maneuvring targets such as bombers. It was also designed to be more suitable for nationwide deployment than the R-113 (SA-1 'Guild').

In 1957 the first operational PVO-Strany (*Voyska Protivovozdushnoy Oborony Strany* — Troops of the National Air Defence) V-75 missile

regiments of three six-rail launcher battalions were formed with one of the initial deployments near the strategically important city of Sverdlovsk. On 1 May 1960 the Sverdlovsk units fired a total of 14 V-750 missiles against a Lockheed U-2 high altitude reconnaissance aircraft flown by Gary Powers of the CIA. The subsequent detonation of the missiles at high altitude not only forced the U-2 to crash, thereby precipitating an international crisis, but also destroyed a Soviet PVO-Strany MiG-19 interceptor. The end result of the incident was that the USA ceased all further U-2 overflights of Soviet territory, losing a valuable strategic intelligence source.

The next incident involving the V-750 was when Chinese People's Liberation Army Air Defence Missile units shot down a Taiwanese-flown Lockheed U-2 over Nanching in September 1962. The V-750 and its locally

built copy, the HQ-1, and derivative, the HQ-2, were subsequently used on many occasions throughout the 1960s against further Taiwanese-flown U-2s and American Ryan pilotless reconnaissance drones, scoring at least another eight U-2s by 1970.

The initial Chinese incident was rapidly followed by the 1962 Cuban missile crisis during which a US Air Force U-2 was lost on 27 October to a V-750 whilst flying over the Cuban naval base at Banes. In mid-1965 the 'Guideline' was introduced into the North Vietnamese Air Defence Network, claiming its first victim, a US Air Force McDonnell Douglas F-4C Phantom, on 24 July. By the end of 1965, 194 V-750s had been fired to destroy five US Air Force (two F-4s and three F-105s) and six US Navy aircraft (one F-4B, one A-4E, two F-8E, one A-6A and one RA-5C).

In 1966 the total rose to 1096 for 34 kills (18 US Air Force — six F-4, five F-105, three RF-101C, two F-104, two RB-66C, 15 US Navy — two A-1H, two F-4B, two F-8E, one RA-5C, three A-4E, five A-4C (plus two A-4C probables), one US Marine Corps — one EF-10). In 1967, 3202 fired for 60 kills (28 US Air Force, 30 US Navy, two US Marine Corps) and from January to the bombing halt in March 1968, 322 for three kills. From the beginning of 1968 to the end of 1971 an unknown number of SAMS were fired to destroy a total of 16 US aircraft (seven US Air Force, eight US Navy and one US Marine Corps). During the 1972 invasion of South Vietnam until the January 1973 ceasefire, the total number of SAMS fired was 4244 (including numbers of SA-3 'Goas' and SA-7 'Grails'). This resulted in the loss of 76 aircraft (54 US Air Force, 22 US Navy — two F-4B, four F-4J, one A-4F, one RA-5C, two A-6A, two A-7A, one A-7B, three A-7C, six A-7E plus one F-8J and two A-7E as probables) and seven helicopters (six US Army, one US Marine Corps). Among the US Air Force losses were 18 Boeing B-52 Stratofortresses, one of which was hit by a V-750 over Vinh on 22 November; 15 others were lost to the V-750 during the Linebacker 2 raids of late 1972. To destroy these aircraft and damage at least four others, the North Vietnamese were logged as firing 1242 'Guidelines' at them using both individual guided launchers and shotgun-like unguided salvos using MiG-21s which shadowed the bomber cells to provide the necessary height and bearing data to the fire control teams. The remaining two B-52s were lost in 1973.

Surprisingly, despite the initial uses of the V-750, it was not until the Vietnam War that the Americans gained the necessary raw intelligence data on the weapon's proximity fuzing system, its terminal phase guidance signals and the warhead's overpressure characteristics at detonation to enable them to design suitable ECM systems to counter it. This was

obtained on 13 February 1966 during a flight over North Vietnam by specially radar enhanced high altitude Ryan 147E ELINT pilotless drone which relayed the information back to a monitoring station until a V-750 destroyed it. This was followed on 22 July 1966 by another special flight involving a Ryan 147F drone protected by onboard ECM equipment. A total of 11 V-750s were fired at the drone before one managed to defeat the ECM coverage and hit it.

In the same year as the V-750 entered the Vietnam War, the Indian Air Force used it operationally during the 1965 Indo-Pakistan War. Obtained in 1963, the first examples of an eventual 25 battalion force were deployed around New Delhi and several of the key airfields in that area. Their only confirmed kill was near Delhi on 6 September when an Indian Air Force Antonov An-12 Cub transport was shot down in mistake for a Pakistan Air Force Lockheed C-130 Hercules. However, during the later stages of the war, the Pakistan Air Force sole high altitude Martin RB-57F reconnaissance aircraft was bracketed by two V-750s at about 15 850 m altitude causing sufficient damage for it to crash land on return to its base. In December 1965 a USAF RB-57F was destroyed by a V-750 on a flight over the Black Sea, near to the Soviet coastline.

Egypt began receiving the V-750 at the same time as the Indians and had 18 battalions in service by the 1967 June war with Israel. They fired only 22 missiles destroying two Mirage IIICJ fighters (on 7 and 8 June respectively) and one complete battalion including radars was captured by the Israeli Army with another eight battalions destroyed by the Israeli Air Force. During the 1968-70 War of Attrition that followed, hundreds of V-750s were supplied to Egypt and the weapon scored its first kill in this war on 9 March 1969 when an Israeli Piper Cub observation aircraft was destroyed. Between then and the 1973 war the number of kills it made increased to about 10, including several F-4E Phantoms, A-4 Skyhawks and a specially configured ELINT Boeing C-97 Stratocruiser.

The V-750 was also used in the 1971 Indo-Pakistan war (one kill, a B-57B at night over Halwara airfield), the 1973 Yom Kippur War (by both Egypt and Syria with 14 assessed kills), the Gulf War (by both sides), by Syria during the 1982 Bekaa Valley air defence battle, by Libya during the March/April 1986 incidents with the Americans, and by Angola against the South African Air Force. It has also been used by North Korea and Cuba on numerous occasions to try and hit American Lockheed SR-71 high-speed high altitude reconnaissance aircraft.

Although when the performance of the weapon is analysed a high number of launches per kill is found, the missile has proved its worth by reducing the accuracy and effectiveness of the enemy's air power by diverting valuable effort to SAM suppression missions, restricting the use of reconnaissance assets and, most importantly, forcing enemy aircraft to adopt tactics or fly lower where other air defence systems such as guns, interceptors or different missile types can prey on their increased vulnerability.

By mid-1988 the number of V-750 launchers in V-PVO (*Voyska Protivovozdushnoy Oborony* — Troops of the Air Defence) regiments had declined to around 2400 from the PVO-Strany peak of over 4600 in the late 1960s. During its long life the weapon had been subjected to numerous modifications, both internally and to its guidance systems. Most of these were prompted by combat experience and the need to rectify problems.

The original V-750 missile (Soviet system designation V-75, US/NATO missile code name SA-2a/ 'Guideline' Mod 0) was first seen in public during the 1957 Red Square parade. The associated E-band missile guidance radar was allocated the NATO code name Fan Song A. It is no longer in operation.

The system was quickly superseded in 1958 by the V75SM system with the marginally longer V-750VK missile (US/NATO code name SA-2b/ 'Guideline' Mod 1) and the NATO code name Fan Song B radar set. The main improvements were incorporated within the missile itself and on the



SA-2 'Guideline' surface-to-air missile on its single rail launcher with reloading trailer in foreground



SA-2 'Guideline' surface-to-air missile partly elevated





Close up of tail of Iraqi SA-2 'Guideline' SAM

radar with the deletion of the original upper parabolic antenna fitted to the vertical orthogonal antenna.

In 1959-60 the V-75M system with the V-750M missile (US/NATO code name SA-2c/'Guideline' Mod 2) and its NATO code name G-band Fan Song C radar entered operational service. The V-750M is identical in appearance to the V-750VK but has a greater maximum engagement range and lower minimum engagement altitude.

During the early 1960s two other Fan Song G-band radars were developed, the Fan Song D (which never actually entered operational service) and the Fan Song E. The latter was associated with the US/NATO code name SA-2d/'Guideline' Mod 3 weapon which appeared around 1961 but is more readily identified with the improved guidance US/NATO code name SA-2e/'Guideline' Mod 4. The SA-2d differed significantly from the SA-2a in having four enlarged dielectric up-link guidance receiver strip antennas under prominent covers on the forward side of the missile instead of the usual two sets of four. It also has a longer barometric nose probe and several other differences associated with the sustainer motor casing. The SA-2e is essentially the same in external layout as the SA-2d but has upgraded internal components and a larger, more bulbous warhead section for either a conventional HE-fragmentation or command detonated nuclear warhead. Unlike the SA-2d the SA-2e was not exported and has remained a solely Soviet operated weapon.

The Fan Song E radar has two parabolic antennas added above the horizontal orthogonal antennas to provide a Lobe-On-Receiver-Only (LORO) electronic counter-countermeasure (ECCM).

During 1967-68, following the extensive combat experience gained on 'Guideline' during the Vietnam War and the capture of a battalion with at least 12 SA-2b missiles with associated Fan Song B radar equipment by Israel in the 1967 Six Day War, the V-75 system design bureau undertook a crash programme to improve the ECCM capabilities and engagement envelope of the Dvina.

Using technology drawn from the more advanced S-125 Pechora, the bureau produced the US/NATO code name SA-2f/'Guideline' Mod 5 missile and Fan Song F radar. Prototype trials were undertaken in late 1968, with the first production battalions being operationally deployed in early 1970. A number of the SA-2f systems were rushed to Egypt for use along the Suez Canal in the latter part of the War of Attrition. Further deliveries were made to Vietnam during 1970-71 for incorporation into its air defence network.

The major changes were in the Fan Song F radar. This reverted back to the original E-band but with a higher output, scintillation suppression, and manual plus mixed mode tracking. The model is readily distinguished from the earlier models by the addition of a small distinctive box-like housing



Close up of centre of Iraqi SA-2 'Guideline' SAM showing the link between the first and second stages (left)

centrally located over the horizontal orthogonal antenna and which replaces the Fan Song E's pair of LORO parabolic dish antennas.

The 'cab' contains the necessary electro-optical tracking and guidance equipment for a two-man team to track a target in a severe ECM environment where the normal automatic electronic tracking mode has been jammed. The optical systems allow target acquisition and missile guidance using the C-band UHF command link at altitudes down to approximately 90 m.

The other significant change in the SA-2f is in the missile guidance package, which now has a capability to home on targets using strobe jamming.

The SA-2 family was used by Iraq during the Gulf War. It is possible that the local Iraqi variant (qv) was also used.

It is expected that the SA-10 'Grumble' (S-300) family will totally replace the SA-2 'Guideline' in Soviet service by the turn of the 20th Century.

#### Description

The V-750 is a two-stage weapon with a large solid propellant booster stage fitted with four very large delta fins. The missile itself has a storable liquid fuel sustainer rocket motor which uses an inhibited red fuming nitric acid/kerosene fuel mix. Towards the mid-section is a set of four cropped delta-shaped wings with a second in-line set of small fixed fins at the nose and a third in-line set of slightly larger powered control fins at the tail. The warhead of the SA-2a/b/c/d/f weighs 195 kg (130 kg of which is HE) and is an HE internally grooved fragmentation type with proximity, contact and command type fuzing available. The 295 kg nuclear warhead for the SA-2e variant is believed to have a yield of 15 kt. The conventional warhead weighs the same.

The warhead of the SA-2a/b/c/e/f models is fitted forward of the main fins and behind the nose-mounted guidance assembly. Maximum blast radius against a high altitude target such as a U-2 is around 244 m due to the rarified atmosphere. At medium to low levels against fighter sized targets the kill radius is about 65 m and the blast radius for severe damage is 100-120 m. The weapon has a CEP figure of 75 m with the large blast radius compensating for any system inaccuracies.

The whole V-75 system, including the launcher, is designed to be simple and easy to operate with the minimum of specialised training. In practically all user countries the pattern of a battalion site is as follows: six semi-fixed trainable single rail launchers are deployed in a hexagon arrangement, about 60-100 m apart. They can either be dug into pits, left at ground level or hardened by being dug in and surrounded by concrete revetments. In the centre of the launchers is the battery command post with the fire control team and its computer, the Fan Song missile control radar, the P-12 (NATO



Close up of nose section of Iraqi SA-2 'Guideline' SAM



Close up of SA-2 'Guideline' on its semi-trailer which transfers the missile directly onto the launcher in 12 minutes



ZIL-157V (6 × 6) tractor truck towing semi-trailer carrying SA-2 SAM under tarpaulin cover

designation Spoon Rest-A truck-mounted or Spoon Rest-B) early warning radar and usually six reload rounds on their articulated trailers. Again, the fire control team, its equipment and the radars can either be van-mounted above ground, simply dug in or located underground in hardened concrete bunkers. Camouflage is used as required.

The battalion's early warning and target acquisition Spoon Rest A-band radar has a range of 275 km using a large Yagi antenna array.

At regimental HQ there is a fourth Spoon Rest, a van-mounted P-15 (NATO code name Flat Face) 250 km range C-band search and tracking radar with two elliptical parabolic reflectors and a PRV-11 (NATO code name Side Net) 180 km range E-band nodding heightfinder radar mounted on a box-bodied trailer. There is also a radar control truck and a Mercury Grass truck-mounted command communications system for linking the HQ to the three battalions.

Once the P-12 and P-15 radars detect a target entering the regiment's assigned defence zone, it is interrogated by the HQ's IFF system (NATO code name Score Board). If designated hostile, the regimental HQ identifies which of its three battalions is the most suitable one for the engagement and transmits the contact details in the form of range, altitude and bearing either by radio or land line from the Mercury Grass command station to the battalions radar elements.

The Fan Song A through to E are normally operated by a four man crew (the Fan Song F has six); a range tracking officer and three enlisted men who serve as angle track operators.

The Fan Songs operate in two basic modes (except the Fan Song E and F systems which have a third intermediate mode for low altitude search and tracking): target acquisition and automatic tracking.

In the target acquisition mode the radar searches for the target to which it has been alerted by the P-12 battalion set. The track-while-scan capability allows it to transfer the data on one target's bearing, altitude and velocity to the fire control computer whilst continuing the scanning to acquire other targets for follow-up tracking. The Fan Song E is able to track up to six targets simultaneously. Once there is sufficient data for the engagement the radar is switched over to its automatic tracking mode and then to its missile guidance mode.

Maximum radar range of the E-band Fan Song A/B/F models varies between 60-120 km depending upon target type, altitude and operating conditions. The G-band Fan Song D/E maximum range is extended to between 75-145 km under the same parameters.

The main element of a Fan Song is the pair of orthogonal trough antennas, one horizontal and one vertical, which emit two 'flapping' fan-shaped radar beams in their respective planes. The separate azimuth and elevation beams of the early Fan Song radars sweep through the target aircraft and a pair of the enlisted men keep the target in the centre of the scan pattern by using manually operated controls.

As already stated the Fan Song E set has an additional LORO ECCM facility built in, whilst the Fan Song F has had this replaced by an electro-optical guidance mode option for use in heavy ECM environments.

In some countries which only deploy early versions of the SA-2, the elderly ground-mounted P-8 Dolphin (NATO code name Knife Rest-A) or truck-mounted P-10 (NATO code name Knife Rest-B/C) radars may be used in lieu of Spoon Rest. They are A-band sets and have an operating range in the order of 150-200 km.

As soon as the computer has a firing solution on a target, a launcher is brought to bear, elevated to between +20 and +80° and blast deflectors erected. Up to three missiles can be fired and controlled against a single target. Launch interval is six seconds.

Once a missile is fired its solid fuel booster is ignited and this burns for 4.5 seconds to take the weapon away from the launch site, 0.5 seconds later the burn out booster unit is jettisoned. After the launch the fire control



Heart of the SA-2 'Guideline' surface-to-air missile system is this Fan Song Radar (F version) system which is deployed together with six launchers (US Department of Defense)

computer continues to receive target data from the Fan Song which is now tracking the missile as well. The computer continually generates commands to guide the missile at the target and these are transmitted over a C-band UHF radio beam up-link to four (on the SA-2d/e or eight on the SA-2b/c) strip antennas mounted forward and aft of the missile's centrebody wings. The onboard guidance unit accepts these and adjusts the missile's trajectory using the movable control fins aft. A V-750 must pick up its narrow UHF line-of-sight guidance beam within six seconds of launch otherwise it goes ballistic and does not guide. The liquid fuel sustainer burns for a total of 22 seconds with the V-750 attaining its maximum velocity only when it reaches around 7630 m altitude.

This means that the missile has limited capability and manoeuvrability when engaging tactical aircraft. Once guided to the vicinity of its target, the weapon's fuzing system is command activated by the fire control computer and this detonates the warhead either by proximity to the target or by receipt of a command signal. A self-destruct unit detonates the warhead after 60 seconds of unguided flight time following launch or after 115 seconds, if closure with the target during guided flight has not been made. Reloading a launcher takes about 12 minutes using the articulated reload trailer and its (6 × 6) tractor.

Over the years various defence techniques have been developed to counter the V-75 models. These include ECM systems, the deployment of large quantities of chaff to confuse the Fan Song guidance radar, and actually out manoeuvring the missile in flight. However, the best to date has proved to be the use of specialist aircraft to suppress the SAM system by electronically and physically attacking it.

#### Variants

The People's Republic of China has developed its own modified version of the V-750 under the designation HQ-2, details of which appear earlier in this section. The licence-built version was the HQ-1 (qv entry this section).

Arab British Dynamics reverse engineered the V-750 'Guideline' to meet the requirements of the Egyptian Air Defence Command, but it was not placed in production. It had the local name Early Bird.

A navalised version, the M-2 (US designation SA-N-2), was tried from 1961 onwards, but proved unsuccessful.

Iraq has modified some of its SA-2 stockpile to accept an infra-red homing seeker (qv).

#### SPECIFICATIONS (missile)

TYPE	two-stage medium to high altitude
LENGTH	
SA-2a	10.6 m
SA-2b/c/e/f	10.7 m
SA-2d	11.2 m
DIAMETER	
booster	0.65 m
missile	0.50 m
MAX SPAN	
booster	2.5 m
missile	1.7 m
LAUNCH WEIGHT	
SA-2a/b/c/f	2287 kg
SA-2d/e	2450 kg
PROPULSION	solid fuel booster with storable liquid fuel sustainer rocket motor command type
GUIDANCE	
WARHEAD	
SA-2a/b/c/d/f	195 kg HE-fragmentation with proximity and/or command fuzing systems



SA-2e	optional 295 kg HE-fragmentation with proximity and/or command fuzing or 15 kt nuclear warhead with command fuzing system
MAX SPEED	
SA-2a/b/c	Mach 3.0
SA-2d/e/f	Mach 3.5
MAX EFFECTIVE RANGE	
SA-2a/b/f	35 000 m
SA-2c	44 000 m
SA-2d/e	50 000 m
MIN EFFECTIVE RANGE	
SA-2a/b/c	9300 m
SA-2d/e/f	7000 m
MAX EFFECTIVE ALTITUDE	27 400 m
MIN EFFECTIVE ALTITUDE	
SA-2a/b	450 m
SA-2c	300 m
SA-2d/e	150 m
SA-2f	90 m
LAUNCHER	single rail semi-fixed trainable
RELOAD TIME	12 mins

**Status:** Production complete. In service with the following countries:

Country	No of launchers	Operator
Afghanistan	18	Air Force (3 battalion)
Albania	24	Air Force (4 battalions including HQ-1/HQ-2)
Algeria	30	Air Force (5 battalions)
Angola	18	Air Force (3 battalions)
Bulgaria	132	Air Force (22 battalions)
China, People's Republic	n/k	Air Force (mostly HQ-2)
Cuba	144	Air Force (24 battalions)
Czechoslovakia	120	Air Defence Command (20 battalions)
Egypt	360	Air Defence Command (60 battalions)

Country	No of launchers	Operator
Ethiopia	24	Army (4 battalions)
Hungary	96	Air Force (16 battalions)
India	150	Air Force (25 battalions, being placed into reserve status)
Iran	60+	Air Force (HQ-2 only)
Iraq	n/av	Army
Korea, North	270	Air Force (45 battalions in 15 Regiments, including HQ-2 model)
Libya	108	Air Defence Command (6 brigades each with 18 launchers)
Mongolia	6	Army (1 battery)
Mozambique	n/k	status uncertain
Pakistan	6	Air Force, HQ-2 version (1 battery)
Poland	240	Air Defence Command (40 battalions)
Romania	108	Air Force (18 battalions)
Somalia	42	Army (7 battalions, status uncertain)
Sudan	30	Army (1 brigade of 5 battalions, status uncertain)
Syria	138+	Air Defence Command (minimum 23 battalions)
USSR	2400	Air Defence Troops
Vietnam	360	Air Defence Force (20 Regiments with 18 launchers each)
Yemen	12	Army/Air Force
Yugoslavia	48	Air Defence Force (8 battalions)

**Manufacturer:** Soviet state factories. Designed by Lavochkin OKB design bureau.

## SA-3 'Goa' Low to Medium Altitude Surface-to-air Missile System

### Development

Known by the name Neva (Soviet river), the S-125 (NATO designation SA-3 'Goa') was developed from around 1956 by the Lavochkin OKB as a low to medium altitude complement to the larger R-113 (SA-1), S-75 (SA-2) and S-200 (SA-5) medium to high altitude surface-to-air missile systems. The name Pechora (Soviet river) was assigned to the export version.

Prototype trials began in 1959 with initial deployment beginning in 1961 at static sites on trainable twin launchers. The missile entered operational service with the PVO-Strany (Voyska Protivovozdushnoy Oborony Strany — Troops of the National Air Defence) missile units for use in airfield defence, low level air defence around long-range SAM systems and the rear area protection of Soviet Army and Fronts in conjunction with the S-75

(SA-2) system. In this last role the missile units are not subordinate to the ground forces but are integrated into the overall Army or Front air defence network. At the same time as the S-125 entered service a navalised version, M-1 Volga-M, achieved operational status with the Soviet Navy aboard cruisers and destroyers. In 1973 a quadruple rail launcher was introduced into service with Soviet Air Defence forces to replace the twin launcher in areas of strategic importance.

The 'Goa' is usually formed into Regiments of four battalions.

The first recorded combat use of the S-125 was in 1970 when Soviet PVO-Strany units, including several 'Goa' missile regiments, were deployed to Egypt with twin launchers to form a joint Egyptian-Soviet air defence network to cover the Suez Canal Zone during the last phase of the 1968-70 Egyptian-Israeli War of Attrition.

Although losing a large number of men and much equipment to Israeli air attacks, the Soviet Union shot down a total of five McDonnell Douglas F-4E Phantoms with the S-125 and were instrumental in forcing on the Israelis the 7 August 1970 UN ceasefire.



ZIL-131 (6 × 6) truck carrying two SA-3 'Goa' SAMs



SA-3 'Goa' SAM four-round launcher deployed in the field



SA-3 'Goa' SAM twin-round launcher



Iraqi SA-3 'Goa' SAM (Christopher F Foss)

The next combat use came in late 1972 when the North Vietnamese used small numbers of S-125s against American aircraft during the Linebacker raids. Their first and only recorded kill was also against an F-4 Phantom of the US Marine Corps. However its major combat test came during the 1973 Yom Kippur War when both Syria and Egypt used large numbers against the Israeli Air Force. The Egyptians started the war with an air defence network of 146 SAM batteries of which approximately a third used S-125s. The Syrians deployed a total of 34 SAM batteries, of which some 15 (including three S-125s) were located between Damascus and the Golan Heights.

The Arab Air Defence networks of both fronts fired around 2100 missiles of the SA-2/SA-3 and SA-6 types to destroy some 46 Israeli aircraft as confirmed kills, of which six were assessed as S-125 victims. However in return the Egyptians lost a number of SA-2, SA-3 and SA-6 batteries which were captured intact by the Israelis and subsequently made available to US Intelligence experts.

Since 1973, the S-125 has been used in combat by Iraq (during the Gulf War), Syria (two batteries in the 1982 air-to-ground Bekaa Valley Air Defence War), Libya (during the April 1986 US Navy and Air Force raids) and Angola (against South African aircraft during various battles in Southern Angola). The SA-3 was used in the 1991 Gulf War by Iraq.

By late 1989 the Soviets still had over 300 S-125 battalion sites in operation, using either four semi-mobile twin or fixed 5P73 quadruple rail launchers. The missile was still in production and had been exported to 26 countries worldwide.

#### Description

The S-125 has a large 2.6 second burn jettisonable solid fuel Isayev OKB booster section fitted with rectangular fins that rotate through 90° at launch. The smaller missile body has an 18.7 second burn Isayev OKB solid fuel sustainer rocket and is fitted with four fixed fins aft and four movable control surfaces forward. After booster jettison the second stage is captured in the radar beam and guidance signals are sent via antenna on the rear fins to place the missile on an intercept trajectory. In the initial 1961 version, US designation SA-3a (NATO designation 'Goa' Mod 0), guidance is by command throughout the flight, while in the definitive version introduced into service in 1964 and known by the US designation SA-3b (NATO designation 'Goa' Mod 1), this has been improved.

Long-range early warning and target acquisition is usually handled by a van-mounted P-15 (NATO designation Flat Face) C-band 210 km range two co-ordinate (azimuth and positional angle) radar with two stacked elliptical parabolic antennas utilising a 5° vertical and 2° horizontal beamwidth. In many S-125 battalions the P-15 has been replaced by the P-15M set (NATO designation Squat Eye) which has approximately the same performance but has had its antenna mounted on a 20-30 m mast to improve the low altitude coverage. A PRV-11 (NATO designation Side Net) 180 km range 32 000 m altitude E-band heightfinder radar is also used.

All target data generated is passed onto the S-125 battalion's organic trailer-mounted fire control radar known by the NATO designation Low Blow. Wherever possible, the four launchers at an S-125 site are positioned in a hand-shaped pattern with the thumb consisting of the revetted long-range search and the palm the Low Blow radar. The latter is controlled from a van or bunker and is optimised for low to medium target monitoring using an unusual antenna configuration of two electromechanically scanned parabolic dishes set above each other and optimised to pick objects out of the ground clutter. Maximum acquisition range is 110 km and tracking range of the I-band system is between 40-85 km depending on the target size, altitude and operational conditions. Radiated beamwidth is 12° in the fan and 1.5° in the direction of scan. It can track six aircraft simultaneously and guide one or two missiles at once. For operating in a heavy ECM environment, late production Low Blow radars have been fitted with 25 km range TV cameras to give the fire control team the same data as from the emitting radar and allow a command guidance interception only to be performed. Against F-4 sized targets at low level the 60 kg HE-fragmentation warhead has a lethal burst radius of 12.5 m. The warhead is armed after the missile has travelled 50 m with the Doppler radar fuze being activated by command signal when the weapon is 300 m from the launcher. If the missile fails to intercept, another signal is sent to either change the trajectory or self-destruct. The trainable launchers are ground-mounted but can be relocated. S-125s are normally transported in pairs from battalion storage areas on modified ZIL-131 (6 × 6) or ZIL-157 (6 × 6) trucks and loaded onto the launchers with the aid of a conveyor. It takes only a minute to load the missiles onto the rails, but the duration between missile launches is about 50 minutes due to missile preparation, truck transit and other reloading procedures.

The missile's ability to dive also allows it to be used against surface targets and naval vessels.

#### SPECIFICATIONS (missile)

TYPE	two-stage, low to medium altitude
LENGTH	6.1 m
DIAMETER OF BOOSTER	0.55 m
DIAMETER OF MISSILE	0.37 m
MAX SPAN	1.22 m
LAUNCH WEIGHT	
SA-3a	946 kg
SA-3b	950 kg
PROPULSION	solid fuel booster with solid fuel sustainer rocket motor
GUIDANCE	
SA-3a	command
SA-3b	command improved
WARHEAD	60 kg HE-fragmentation with Doppler radar proximity and contact fuzes
MAX SPEED	Mach 3.5
MAX EFFECTIVE RANGE	
SA-3a	22 200 m
SA-3b	18 300 m
MIN EFFECTIVE RANGE	
SA-3a	5600 m
SA-3b	2400 m
MAX ALTITUDE	
SA-3a	12 200 m
SA-3b	18 300 m
MIN ALTITUDE	
SA-3a	1500 m
SA-3b	45 m



LAUNCHER twin or quadruple rail semi-fixed trainable ground mount  
 RELOAD TIME 50 mins (quadruple launcher)

Status: In production. In service with:

Country	No of launchers	Operator
Afghanistan	12	Air Force (3 battalions with quad launchers)
Algeria	20	Air Force (1 battalion), Army (4 battalions)
Angola	48	Air Defence Force (12 battalions)
Bulgaria	136	Air Force (34 battalions)
Czechoslovakia	120	Air Defence Command (30 battalions)
Cuba	48	Air Force (12 battalions)
Egypt	220	Air Defence Command (55 battalions)
Ethiopia	20	Army (5 battalions)
Finland	12	Army (3 battalions with quad launchers, as SAM-79)
Hungary	24	Air Force (6 battalions)
India	48	Air Force (12 battalions with quad launchers)
Iraq	n/av	Army
Korea, North	32	Air Defence Command (8 battalions in 2 Regiments)

Country	No of launchers	Operator
Libya	132	Air Defence Command (9 brigades of 12 launchers and 6 battalions of 4 launchers)
Mali	12	Army (independent batteries)
Mozambique	12	Army (3 battalions)
Peru	12	Air Force (3 battalions)
Poland	200	Air Defence Command (50 battalions)
Somalia	8	Army (2 battalions) (status uncertain)
Syria	160	Air Defence Command (40 battalions)
Tanzania	8	Army (2 quad launcher batteries)
USSR	1250	Air Defence Troops, 300 sites
Vietnam	160	Air Defence Force (10 Regiments)
Yemen	12	Army (3 batteries)
Yugoslavia	140	Air Defence Force (35 battalions)
Zambia	12	Air Force (1 battalion of 3 batteries)

Manufacturer: Soviet state factories.

## SA-5 'Gammon' Medium to High Altitude Surface-to-air Missile System

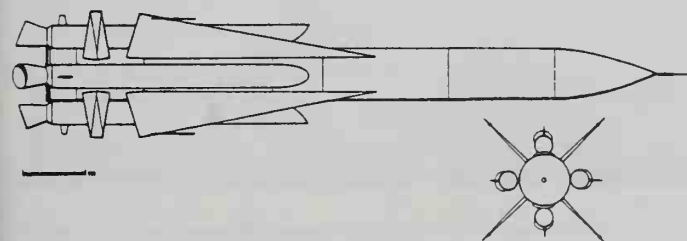
### Development

Development of the S-200 Volga (Soviet river), US/NATO designation SA-5 'Gammon', was begun in the early 1950s by the PVO-Strany (*Voyska Protivovozdushnoy Oborony Strany*—Troops of the National Air Defence) Voisko design bureau to meet a requirement for a long-range medium to high altitude surface-to-air missile to complement the R-113 (SA-1) and V-750 (SA-2) weapons, as neither was considered sufficient to deal with the projected new generation of American high speed high altitude penetrating strategic bombers such as the North American B-70.

Initial deployment of an S-200 trials unit using the Israeli designation SA-5a model, occurred in 1963-4 on the outskirts of Tallinn in Estonia. The first operational Regiments were deployed in 1966 with 18 sites and 342 launchers in service by the end of the year. By 1967 the site total had risen to 22, by 1968 40 and by 1969, 60. The growth in numbers then gradually increased throughout the seventies and early eighties, following the reorganisation of the PVO-Strany into the V-PVO (*Voyska Protivovozdushnoy Oborony*—Troops of the Air Defence) in 1981, until the peak of 130 sites and 1950 launchers was reached in 1985-6. The numbers deployed have stabilised at around these totals since 1986.

However, the R-113 (SA-1), S-75 (SA-2), S-125 (SA-3), S-200 (SA-5) and later missile systems remained under the control of the ZRV (*Zenitayye Raketnyye Voyshky*—Zenith Rocket Troops) component with the addition of all mobile surface-to-air systems from the former troops of Troop Air Defence of the Ground Forces.

Over the years a number of SA-5s have apparently been fired by Soviet Air Defence Troops against Lockheed SR-71 strategic reconnaissance aircraft without success.



Provisional drawing of the SA-5 'Gammon' SAM, (Steven Zaloga)

The missile has gone through periodic updates with a nuclear warhead equipped version, the Israeli designation SA-5b entering service in 1969-70. This was followed by the definitive version, the Israeli designation SA-5c in 1975-76 with improved terminal guidance and dual nuclear or conventional warhead capability.

In 1983 the Soviets first began to establish 'Gammon' sites in Warsaw Pact territory with battalions positioned in the former East Germany (near Rostock and Rudolstadt), Czechoslovakia (near Plzen) and western Hungary (near Szombathely). Before this the only known site outside official Soviet borders was in Mongolia.

Also in the wake of the Syrian Air Defence *débâcle* in the Lebanese Bekaa Valley during 1982, the Soviets sent four six-launcher battalions to Syria in late 1982 early 1983. Two sites were activated: Dumayr (40 km east of the capital Damascus) and Sharsar (in north-east Syria to the south-east of Homs). Initially manned by Soviet V-PVO troops, they were turned over to the Syrian Air Defence Command in 1985 to initially form two, then four two-battalion Independent Air Defence Missile Regiments with the additional sites located at As Suwayda and Mesken.

Following the Syrian success in obtaining S-200s, Libya began negotiations for some in 1984 with the first of three brigades delivered the following year. Operated by the Libyan Arab Air Defence Command, each brigade comprises two six-launcher S-200 battalions and two four quadruple launcher S-125 battalions. On 24 March 1986 the S-200 brigade at Sirte on the Gulf of Sidra launched at least five missiles at US Navy aircraft operating in international airspace. All missed and the brigade's radars were subsequently attacked by US Navy aircraft firing ARMs on at least two occasions during the 'mini-war' of 24/25 March. The other two sites are at Benghazi and Oka Ben Nafi.

In the Soviet Union the S-200 has, for a number of years, been organised into Air Defence Rocket Brigades, each of two or three Regiments with two five-S-200 battalions of six launchers each (arranged in circles around the battalion's Square Pair radar) and two or three battalions of S-125s each with four quadruple launchers to provide low altitude cover of both the installations being guarded and the S-200 battalions. In addition, each of the SAM battalions has a sub-unit of automatic anti-aircraft (AAA) guns of either light (23 mm ZU-23) or medium (57 mm S-60) calibre.

In late 1987 North Korea took delivery of SA-5 systems for use in the Korean People's Air Force (KPAF) Air Defence Command.

The first SA-5 regiment of two six-launcher battalions was deployed to the Sarilwon-Pyonsan area, some 40-100 km north of the DMZ, with the second regiment located on the east coast in the Wonsang-Hamhung region. Both units can reach into the northern sectors of South Korea's airspace threatening both AWACS aircraft and strategic stand-off reconnaissance assets like the Lockheed TR-1/U-2R and Boeing RC-135 ELINT/COMINT aircraft.

The regiments are integrated with the advanced 1980s technology Soviet Tin Shield 350 km range mobile early warning (EW)/ground control intercept



SA-5 'Gammon' SAM on its trainable launcher



Square Pair missile guidance radar used with the SA-5 'Gammon' SAM

(GCI)/target acquisition jam-proof radar system optimised for low level coverage and supplied at the same time. The radars also serve the four SA-2 'Guideline' brigades (with a total of 15 regiments) and the two independent SA-3b 'Goa' regiments already in service with the KPAF.

The entire country comprises a single air defence district with all operations controlled from the Combat Command Post (CCP) located at the KPAF HQ, Pyongyang.

The district is subdivided into three Sector Commands: North-West, North-East and Southern and the Pyongyang air defence subsector.

Each Sector consists of an HQ, an air direction control centre (ADCC), EW radar regiment(s), air defence fighter division(s), SAM regiment(s), an AAA division and other independent AAA units.

When a target is detected, fighters are alerted and launched whilst the SAM and AAA units initiate tracking. Any subsequent SAM or AAA engagement is then co-ordinated with the fighter division's HQ and the CCP. The idea being that if the aircraft are unable to engage or are unsuccessful in their interception then the SAMs deployed in 'belts' will either destroy the target or force it, by virtue of making it take evasive action, into a position where covering AAA in 'ambush' positions are able to effect its destruction.

The SA-2 regiments of three six-launcher battalions each are deployed mainly in a west coast 'belt' that runs along the Kaesong-Sarlwon-Pyongyang-Pakch'on-Sinuljus axis and two east coast 'belts' that lie along the Wonsan-Hamhung-Sinp'o and Chongjin-Najin lines. A number of independent 'Guideline' regiments are located in 'dead' areas and around strategic areas between these 'belts'.

The SA-5 regiments are used to support these 'belts' as are the two SA-3b units of four four-quadruple launcher battalions each, one in the west and the other in the east.

The SAM force, based on the Soviet practice of three ready missiles per launcher, disposes of a total of over 1200 missiles - 810 SA-2, 384 SA-3 and 72 SA-5. With the strategic war storage stock added the grand total is increased to the 2500-3000 round level.

The individual SA-2/3/5 sites generally follow the Soviet patterns except that the majority of their EW, target acquisition and GCI radars are located either in large underground concrete-reinforced NBC protected bunker complexes or dug into mountains. The sites comprise a tunnel, control room, crew quarters and steel blastproof doors. An elevator raises the radar to the surface when required. There are also many dummy radar and SAM sites together with genuine alternative site positions for the SAM launchers.

#### Description

The HQ unit of an S-200 Regiment has a radar section with a single NATO designation Big Back L-band 500 km range plus early warning radar.

Each missile battalion has one P-35M (NATO designation Barlock-B) E/F-band 320 km range target search and acquisition radar with an integral D-band IFF system, one H-band NATO designation Square Pair 270 km range missile guidance radar, and six trainable semi-fixed single rail launchers.

The missile itself is of the single-stage type with four jettisonable, wraparound solid fuel booster packs. Each booster is 4.9 m long, 0.48 m in diameter and has a single fin span length of 0.35 m from the booster body. The S-200 is 10.72 m long overall and has a maximum wing span of 2.85 m. The main body is 0.85 m in diameter and has a solid fuel dual thrust sustainer rocket engine.

The minimum range of 60 km or so is due to the booster burn time and jettison requirements which limit it to engagements against relatively large unmanoeuvrable targets at ranges up to 250 km. Guidance beyond the 60 km booster jettison point is by course correction command signals from the Square Pair radar with the S-200's own active radar terminal homing seeker head being activated near to the projected intercept point for the final guidance phase. The large HE warhead is detonated either by a command signal or the onboard proximity fuzing system. When fitted with a nuclear warhead only the command detonation option is used.

#### SPECIFICATIONS (missile)

TYPE	single stage, medium to high altitude
LENGTH	
overall	10.72 m
missile body	10.50 m
DIAMETER	0.85 m
MAX SPAN	2.85 m
LAUNCH WEIGHT	2900 kg
PROPULSION	four solid fuel strap on boosters with storable liquid fuel rocket motor
GUIDANCE	SA-5a/b/c command with active radar terminal homing seeker
WARHEAD	HE-fragmentation (SA-5a/c) or 25 kt yield nuclear (SA-5b/c) with proximity and command fuzing
MAX SPEED	Mach 4 plus
MAX RANGE	250 km
MIN RANGE	60 km (possibly considerably less)
MAX ALTITUDE	30 480 m
MIN ALTITUDE	300 m
LAUNCHER	static semi-fixed single rail trainable

Status: Production complete. In service with:

Country	Quantity
Bulgaria	small number of sites
Czechoslovakia	small number of sites
Germany	2 sites remaining, to be replaced by I-HAWK/Patriot units
Hungary	one battery
Iran	Air Defence forces (from 1992)
Korea, North	Air Defence Command
	4 x 6 launcher battalions
Libya	6 x 6 launcher battalions
Poland	2-3 sites
Syria	4 x 6 launcher battalions
USSR	130 sites with total of 1930 launchers

Manufacturer: Soviet state factories. Designed by the PVO-Voisko design bureau.



## UNITED KINGDOM

### British Aerospace Rapier Low Level Surface-to-air Missile System

#### Development

The Rapier low level surface-to-air missile system was developed by the former British Aircraft Corporation, Guided Weapons Division, from the early 1960s onwards to meet the requirements of the British Army and Royal Air Force Regiment for a missile system to replace the 40 mm L/70 Bofors air defence guns then in use.

The operational requirements laid down for Rapier can be summarised as short reaction time with the ability to be taken into and out of action quickly, compactness and low weight, high rate of fire and kill potential, good defence coverage with maximum/minimum range performance and the ability to engage targets with speeds from zero to Mach 1.5 from ground level up to at least 3000 m.

Before receiving MoD funding for the ET-316, the British Aircraft Corporation invested its own money in a simpler weapon then called Sightline which eventually became ET-316, or Rapier as it was officially named in January 1967.

Design studies began in 1963 and Rapier was announced for the first time in September 1964 with the first unguided firing trials carried out in 1965.

In April 1967 the first successful guided engagement of a live target took place at the RAE range at Aberporth. This was a drone Meteor representing a crossing target and was flying at an altitude of 914.4 m at a range of 3048 m from the firing site. The target was hit and destroyed. Joint Services evaluation trials of the Rapier at the Woomera range commenced in 1968.

The first production order was placed by the British MoD in June 1967 and the first production units delivered in July 1970. The system achieved initial operational capability with the British Army and Royal Air Force in 1973. In addition to extensive trials in the UK, cold weather trials were carried out at Cold Lake in Alberta, Canada, and hot and wet trials were carried out in Australia.

Troop trials of towed Rapier were carried out by 9 (Plassey) Light Air Defence Battery, Royal Artillery, based at Kirton-in-Lindsey, which also included a flight from No 63 Squadron, Royal Air Force Regiment. Kirton-in-Lindsey was the base of the Royal Artillery's first Rapier regiment, 12 Light Air Defence Regiment.

The British Army has three air defence regiments equipped with Rapier, of which two are in BAOR and one in the UK. Originally each regiment had three batteries, each battery with three troops of four Rapier fire units to give a total of 36 per regiment. The Regiments in BAOR, however, have been re-equipped to field two batteries with Towed Rapier and two batteries with Tracked Rapiers.

Under the British MoD's Options for Change programme, the Royal Artillery will in the future have four air defence regiments, two with Towed Rapier and two with the self-propelled Shorts Starstreak HVM system.

In the British Army, Rapier is used as the second and third line of battlefield air defence. The first is the Javelin and Starburst manportable systems which is used as a gap filler for the Rapiers, as a Vital Point (VP)



*Four-round Rapier missile launcher deployed ready for action with wheels removed and supported on four jacks (MoD)*

defence system and a route defence system. The second line is provided by Tracked Rapier Vehicles and the third by the Towed Rapier systems.

Towed and Tracked Rapiers are employed in three main roles. VP defence is used to give localised protection to small sized target locations such as HQs, vehicle choke points and logistic dumps. Each VP is allocated either four or six launchers. They are deployed in such a manner as to give mutual support and to try to destroy an attacker before it releases weapons. The Battery Command Post (BCP) normally co-ordinates the VP defences, but if a troop is allocated an independent VP task, command and control devolves to the troop commander.

The second mission role is route defence of main supply or unit withdrawal routes. A battery can protect up to 30 km although this depends greatly on the local terrain. Two fire units are normally located at each end of the route to be defended in 'blocking' positions, and the other eight are deployed between 1-2 km off the line-of-march in alternate positions either side of the route.

It is the third mission role, however, that is used most often as it covers the largest area of battlefield. The Air Defended Area (ADA) can be used to cover both VPs and routes with a battery's tactical area of responsibility (TAOR). Once assigned this task, the troop commanders and their staff reconnoitre likely firing positions within their TAORs and send the details back to the BCP either by burst transmission radio message or courier.

The Battery Commander and his Command Post officer feed the information into the BCP processor which selects the best 12 sites and a number of reserve sites according to firing arcs and radar coverage.



*Royal Air Force Regiment Rapier deployed in the field with Rapier launcher in background, optical tracker centre and Marconi Radar and Control Systems Blindfire tracker in foreground*



*British Aerospace Rapier fire unit deployed in Oman with optical tracker in foreground and four-round launcher in background*



British Aerospace Rapier SAM leaves its four-round launcher

When this is finished the fire units are moved to their new locations. For a Tracked Rapier battery the same three mission roles can be assigned but because of increased mobility the individual fire unit commanders have much more latitude and can move on their own initiative when the position they are occupying becomes undefendable. For support of armoured units in direct combat with the enemy, the Tracked Rapier elements will be located a number of kilometres behind in order to remain out of range of enemy fire weapons.

Rapier was used by 'T' Battery of 12 Air Defence Regiment, Royal Artillery, during the 1982 Falklands campaign. A total of 12 launchers were deployed with reduced logistic support and no Blindfire radars.

At the time of the Falklands Conflict the UK Rapier force was undergoing a systems upgrade to improve its performance, but the Rapier unit deployed to the Falklands was the original Field Standard A model.

Rapier was in action from the first day of the landings in San Carlos water on 21 May through to the end of hostilities, by which time the official UK Government White Paper (*The Falklands Campaign: The Lessons*) stated that at least 14 Argentine aircraft were destroyed by Rapier with another six possibles. However, other sources have since suggested that Rapier actually shot down only one IAI Dagger A and assisted in the destruction of a McDonnell Douglas A-4C Skyhawk.

'T' Battery of 12 Air Defence Regiment was followed by four Blindfire radars from the Royal School of Artillery, eight Rapiers and Blindfire radars from 63 Squadron, Royal Air Force Regiment and finally 9 Battery, 12 Air Defence Regiment. The Blindfire radar was never used in action.

Rapier was, however, first used in combat by Iran in the second half of 1972 when it shot down an Iraqi Air Force Tu-22 Blinder supersonic bomber attacking Kurdish rebels in the Iran/Iraq border region. During the Gulf War, Rapier was responsible for a number of Iraqi Air Force losses.

A typical fire unit consists of a 1 ton Land Rover carrying the optical tracker and towing the four-round launcher and generator power supply, a 1 ton Land Rover towing Blindfire radar (if used), and generator power supply and a  $\frac{3}{4}$  ton Land Rover carrying nine reserve missiles.

Each battery also has a battery HQ and a repair section which has a  $\frac{3}{4}$  ton Land Rover equipped with diagnostic and performance test gear and tows a trailer carrying a quantity of ready use spares. There is also a battery repair team with two vehicles, one for optical and hydraulic repairs and the other for major electronic repairs, and an ordnance spares vehicle.

The first Royal Air Force Regiment unit to receive Rapier was No 63 Squadron based at North Luffenham, UK, and this was subsequently deployed at Gutersloh, West Germany, in mid-1974.

The second unit to be equipped was No 58 Squadron which was deployed to RAF Laarbruch, West Germany. No 27 Squadron was the first to receive the Blindfire radar in late 1977.

A Royal Air Force Low Level Air Defence (LLAD) Rapier squadron comprises an HQ flight, an engineering flight of four forward repair teams (of which two are for Rapier) and a second echelon maintenance section and two Rapier flights, each with four fire units. The latter comprise eight men, a towed Rapier launcher, a Blindfire radar tracker, two 1 ton 4 x 4 light vehicles and an LWB Land Rover with missile resupply trailer. A basic load of 17 missiles for the unit is carried.

Since it was introduced into the British Army and Royal Air Force Regiment in the early 1970s, there have been a series of phased developments not only to improve the performance of the system but also to maintain the system ahead of the threat which is constantly changing. In mid-1987, for example, the British MoD placed an order with British Aerospace worth over £5 million for the supply of new digital computers for

the Rapier air defence systems to replace older computers. By 1987 more than 50 per cent of the launcher's major assemblies comprised 1980s technology including the key areas of computing and radars. This has had a significant effect on Rapier system reliability as well as increasing system automation.

These modifications are incorporated into current production systems and are offered to current Rapier users as part of a programme of modifications.

By 1991 the total signed orders for towed Rapier and Tracked Rapier exceeded 700 fire units and 25 000 missiles, of which more than 12 000 missiles have been fired during development, training and combat.

Individual parts of the towed Rapier air defence system can be carried slung under medium or heavy lift helicopters such as the Aerospatiale SA330 Puma and Boeing Vertol CH-47 Chinook, a C-130 Lockheed Hercules transport can carry one complete system with Blindfire radar tracker or two optical systems with vehicles.

For the export market, Rapier is tailored to meet the specific requirements of each customer, but the British armed forces use designations to avoid confusion.

The basic Rapier, together with its Blindfire radar, is called Field Standard A (FS A). This was followed in 1979/80 by Field Standard B1 (FS B1) that has a free-standing tripod-mounted 'pointing stick' which, when pointed at a target and activated by pressing a trigger, aligns the optical tracker automatically. There are also improvements to both ECCM and ECM including an improved planar array antenna and an automatic code changer for the IFF.

In 1985 troop trials began of the Field Standard B2 (FS B2) electro-optical system, known as Rapier Darkfire. This involves the introduction of an infra-red tracker which replaces the optical unit, a new six-round launcher incorporating an improved planar array Racal-Decca surveillance radar with a 50 per cent range increase, an automatic code changer for IFF and the Console Tactical Control system for the fire unit commander. First deliveries were made in 1988. The completion of programmed deliveries, which total three batteries of FS B2 systems plus support, spares and maintenance, were achieved by the end of 1990.

By using an analogue digital interface unit a standard Blindfire radar tracker can also be used with Rapier Darkfire where an all-weather capability is required.

The Field Standard C Rapier 2000, which is usually referred to as Rapier 2000, has a separate entry in this section.

### Description

The main component of the towed Rapier system is the launcher which is carried on a two-wheeled A-frame trailer. When in the firing position the wheels are removed and it is stabilised on four adjustable legs. The engagement envelope is from  $-5$  to  $+60^\circ$  in elevation and  $360^\circ$  in traverse. The Racal-Decca 15 km maximum range 3000 m altitude capability F-band surveillance radar aerial, on which the Corsor IFF aerials and interrogator are mounted, is housed under the radome and rotates once every second. The radar transmitter receiver is mounted in the lower part of the launcher.

The radar, together with the IFF, provides for the early detection and warning of approaching aircraft and helicopters. The launcher turntable rotates through  $360^\circ$  and carries four missiles in the ready to launch position, two on each side. The command transmitter and aerial which provides the link between the computer in the base of the launcher and the missiles in flight is located between the two banks of two missiles.

The optical tracker stands on a tripod which has a levelling jack on each leg and consists of a static column with a rotating head providing  $360^\circ$  coverage in azimuth. Elevation coverage between  $-10$  to  $+60^\circ$  is provided by movable prisms in the rotating head. The wide field-of-view is  $20^\circ$  and the narrow field-of-view  $4.8^\circ$ . Operation is normally controlled by the computer with operator override at any time to select the narrow option.

The manual tracking system is optical, with the operator using a joystick operated servo-driven unit to track the target. The guidance system uses a fully automated TV system which gathers the missile in flight after launch using an  $11^\circ$  field-of-view, then automatically switches over to a  $0.55^\circ$  field-of-view to guide it to interception with the target.

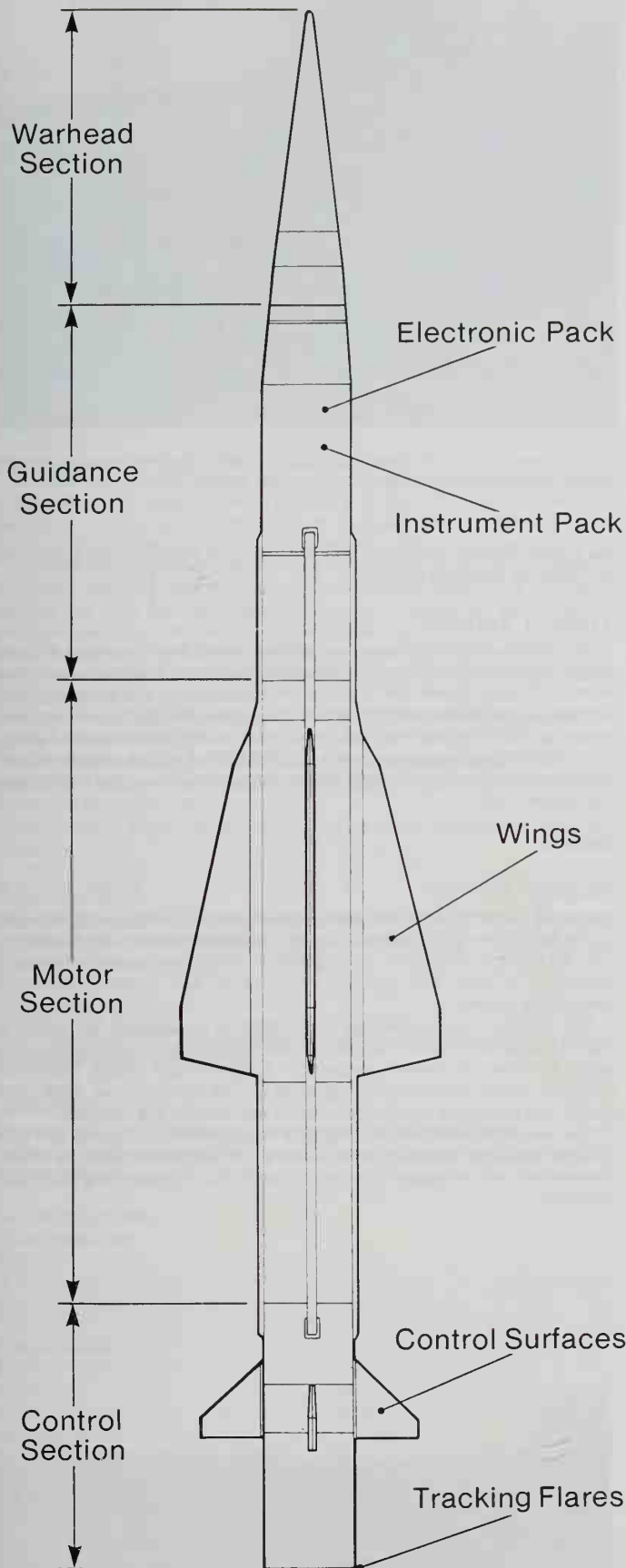
The operator is provided with a biocular sight for target tracking and has a few simple controls to operate the system. A second monocular sight is provided at the rear of the static column which an instructor can use to monitor students' performances during field training.

The Tactical Control Unit (TCU) provides tactical control facilities and is connected by cable between the launcher and optical tracker. It is divided into 32 sectors in azimuth, each sector covering  $11.25^\circ$ . By operating sector switches blind arcs can be built up as required to provide 'safe' channels for friendly aircraft or to set in priority arcs of fire.

The Rapier missile has a streamlined monocoque body of circular cross-section and consists of four main sections; warhead, guidance, propulsion unit and control.

The 1.4 kg warhead section contains the semi armour-piercing warhead, with 0.4 kg of explosive, a safety and arming unit and crush fuze. A collapsible plastic nose cone is fitted to the penetration head to provide optimum aerodynamic shape.





*Drawing of the BAe Rapier Mk 1 SAM showing position of key components*

The guidance section is in two parts; the electronic pack and the instrument pack. The Imperial Metal Industries Troy propulsion unit is an integral dual thrust two-stage rocket motor and gives the missile a maximum speed of around 650 m/s. The control section contains the hot gas-driven control surface actuation mechanism, which controls the missile in flight, and pyrotechnic flares to facilitate TV gathering and tracking. The same Mk 1 missile is used for both the optical and Blindfire guidance modes and for

Tracked Rapier. A missile flying to maximum range takes 13 seconds with the minimum time of flight (required to arm) being three seconds. The single shot kill probability is stated to be over 70 per cent.

Rapier is manufactured as a round of ammunition and requires no maintenance testing or servicing once it has left the ordnance depot except for routine changing of desiccators. When stored in controlled conditions the missile has a shelf-life of 10 years.

In May 1988 BAe trialled the hybrid Rapier Mk 1E missile design against RPV-sized battlefield targets. The Mk 1E uses the propulsion system of the existing Mk 1 weapon with an advanced 'intelligent' passive infra-red proximity and graze fuze system and a revised pre-formed HE-fragmentation warhead. It is envisaged that the missile will complement rather than replace the current Mk 1 to enhance the system's capabilities against smaller sized aerial targets. Production started in 1989.

British Aerospace (Dynamics) has now developed and placed in production the Mk 2 Rapier missile, this is fully compatible with all versions of the Rapier missile system including Optical Rapier, Blindfire Rapier, Tracked Rapier, Rapier Darkfire and Rapier 2000.

The 43 kg Mk 2 missile exists in two versions and has a 15 to 20 per cent increase in range. One version will retain the semi armour-piercing warhead, of the original, the other will have a combined fragmentation and armour piercing warhead and dual crush and proximity fuzes.

THORN EMI Electronics produced a small pre-production order of the active infra-red (IR) fuzes for the Rapier Mk 1Ib missile in 1990. Full production of the fuze began in mid-1991 as a milestone objective in the £10 million development and initial production contract awarded to the company in 1986.

The fuze system comprises an IR laser transmitter and four quadrant receiver optics units, coupled with intelligent signal processing to determine the optimum range to target position at which detonation of the fragmentation warhead is to be initiated.

The DN181 Blindfire K-band 10 km range radar was developed by Marconi Radar and Control Systems to enable Rapier to cope with the night and all-weather threat. The non-coherent frequency-agile radar was designed to meet the same characteristics of size, light weight and mobility as the rest of the system; it is therefore trailer-mounted and can be simply plugged into any Rapier system.

In operation, the monopulse radar employs differential tracking of both the missile and target using a very narrow pencil beam to achieve the accuracy required.

Marconi commenced development of the Blindfire radar under contract to the MoD in 1968 with first prototypes completed in 1970. The first pre-production system was handed over in 1973 and the main production order was placed the same year, with Iran placing its first order in 1974. The Blindfire radar has also been successfully tested with the US Chaparral SAM system during trials in the USA. By 1991 over 350 had been built for the home and export markets with production continuing.

The Blindfire radar is mounted on a chassis which is similar to the launcher and when deployed for action the wheels are removed and it is supported on four adjustable legs. The base housing contains the electrical, electronic and hydraulic power assemblies and is static during operation.

The upper assembly carries the main reflector and sub-reflector assembly, the TV gathering unit with its power supply and the RF unit. This assembly rotates in azimuth and the aerial system in elevation.

The addition of Blindfire allows Rapier to engage targets successfully in darkness and poor visibility. As it is autonomous the target tracking and acquisition process decreases system reaction time, increases kill probability and reduces human operations to a monitoring role. Once a target has been picked up by the surveillance radar, the azimuth bearing is passed automatically to the Blindfire tracking radar which slews rapidly onto this bearing. A high speed search pattern is carried out and the precise position of the target is established.

As soon as the tracking radar is locked onto the target, the operator is informed by an audio tone that the radar is tracking and then he switches to the radar mode to allow the tracking radar to control the Rapier system. Immediately the target comes within range, a lamp indicator tells him he is free to launch a missile. All the operator has to do is to press the launch button.

Once the Rapier missile is launched, the tracking radar tracks both the target and the missile. Error signals are derived automatically within the radar system and passed to the command guidance unit which uses encoded signals to direct the missile flight path to reduce the error angle to zero.

Blindfire uses a standard Rapier generator and requires only the cable connection to the launcher unit and to the lamp indicator system control switch on the optical tracking unit.

The system control switch enables the operator to select either radar or optical guidance for the engagement at any point up to the moment of firing.

A mobile optical fire unit consists of two Land Rovers (or similar vehicles), the launcher and a light trailer.

The first Land Rover carries the optical tracker, four missiles in their travelling boxes, and tows the launcher with its generator set rear-mounted. The second Land Rover carries stores and supplies for the fire unit and tows the missile resupply trailer, carrying a further nine missiles in their



*Marconi Radar and Control Systems Blindfire radar deployed in the field*

travelling boxes. The fire unit can be brought into and out of action in under 20 minutes and can be manned by three men, although five are normally used for sustained operations. Rapier can also be integrated into an overall air defence system.

An optical fire unit can be converted into a Blindfire unit simply by the addition of a Blindfire Radar towed by a third Land Rover, which is similar to that which tows the launcher. It carries four missiles in their travelling boxes and tows the Blindfire unit with its generator set rear-mounted.

A fully mobile Blindfire fire unit thus consists of three light vehicles, three light trailers, with a total of 17 ready use/reload missiles. In terms of capabilities, it has its own surveillance radar, IFF system, guidance computer, day, night and all-weather tracking systems, ready use and resupply missiles and power supply units. It can thus operate autonomously or be integrated, with the necessary communications system, as part of an air defence network.

A typical Rapier target engagement takes place as follows:

The surveillance radar is continuously rotating through 360° looking for aircraft or helicopters which come within range. When detected, a target is automatically interrogated by the Corsor IFF system. If no friendly reply is received the operator is alerted by an audible signal in his headphones. At the same time, the rotating head on the optical tracker and radar tracker automatically lines up with the target in azimuth followed by the launcher. The radar tracker then begins its automatic elevation search while the operator undertakes a manual visual search. If a radar tracker is available it will be used as the prime means of target engagement and the procedure will be as described, however an alternative manual engagement procedure can be used. The operator then undertakes an elevation search to acquire the target, after which he switches to the track mode and begins to track the aircraft visually using a joystick control. He is then able to identify the aircraft visually. Information from the optical tracker and the surveillance radar are fed into the system computer in the launcher and this data is used to calculate whether or not the aircraft is within effective range of the system.

When the aircraft comes within firing range a visual signal appears in the operator's field-of-view and he immediately presses the firing button to initiate a missile launch.

The computer calculates toe in and turns the launcher towards the optical line-of-sight. The missile is automatically gathered along the sight line by the TV system until impact. During the missile flight the only task of the operator is to keep tracking the target.

The missile has a semi armour-piercing warhead which penetrates the aircraft skin. The crush fuze detonates the high explosive inside the aircraft, causing the target to be destroyed. This contact technique has caused Rapier to be known as a 'hitille' system.

Once the target has been engaged the operator can switch back to search so that another engagement sequence can be immediately started, or a second missile may be launched at either the same target or another target in the operator's field-of-view.

Four replacement missiles can be reloaded by a trained crew in less than 2.5 minutes. The surveillance radar can detect low-flying targets in the presence of heavy ground clutter out to a range of more than 15 km and the missile itself can engage targets at 7000 m, giving an overall intercept coverage of 150 km<sup>2</sup> per fire unit. Numerous firings have demonstrated that



*Land Rover 1 ton (4x4) vehicle of Royal Air Force Regiment towing Marconi Radar and Control Systems Blindfire radar system*

the system reaction time (from when the target is detected until a missile is launched) is about six seconds.

## Towing Vehicle

In the British Army, the Rapier is normally towed by a 1 ton (4x4) Land Rover. Following trials, in 1990 the Royal Air Force Regiment placed an order with Land Rover for 214 long wheelbase 127 V-8 powered Land Rovers to tow Rapier systems in both the United Kingdom and overseas, including USAF (locally manned) units in the United Kingdom and Turkey.

For Operation Granby, a number of SUPACAT (6x6) all-terrain vehicles were modified for use as Towed Rapier Support Vehicle's and deployed to the Middle East.

## Variants

### Rapier Darkfire

Known by the British MoD as Electro-Optical Rapier this was being delivered to the British Army in 1988 with the first complete battery. No 14 battery, 16th Air Defence Regiment, undergoing an operational acceptance trial in mid-1989. It uses data highways throughout and a distribution data processing system.

The launcher has six missiles in the ready to fire position, compared to four in the current system and has a new Racal-Decca surveillance radar which provides increased acquisition accuracy and range, helicopter detection mode, considerably improved ECCM (including an ARM quiet mode) and enables a radar display to be provided for the operator.

The new distributed processor greatly increases the computing and data storage capacity offering more automation, improved multiple threat assessment and the instant retrieval of system data for testing and diagnostic purposes.



*Rapier Darkfire deployed in field with six-round launcher (centre), operator (left) and electro-optical tracker (right)*





Land Rover 127 of the Royal Air Force Regiment towing Blindfire radar

The standard Rapier optical tracker has been replaced by an electro-optical tracker (or thermal/video) providing a day/night and poor visibility capability. The complete system can be plugged into the standard radar tracker using an interface box when all-weather capability is required.

The new tactical control unit provides a colour TV display of surveillance radar data including aircraft tracks with their identification and electronic interference. Also on the display are range intervals and a number of functional markers. The operator therefore has a complete picture of the air scenario from which to conduct threat assessment routines and fight the air battle. The display's secondary function is to display test and diagnostic data stored in the processor.

It will not be issued to the Royal Air Force Regiment as they have chosen to wait for Rapier 2000.

The original petrol-engined generators have also been replaced by more reliable and quieter diesel-powered generators supplied by Commercial Hydraulics Keelavite Ltd.

The system is being marketed for export under the designation Improved Rapier.

## Rapier 2000

Details of this system, currently under development for the British Army and Royal Air Force Regiment and expected to enter service in the 1990s, are given in the following entry.

## Tracked Rapier

This is covered in the *Self-Propelled Surface-to-Air Missiles* section and is deployed only by the British Army.

## Laserfire

Details of this private venture system, which can be mounted on a variety of tracked and wheeled chassis, is given in the *Self-Propelled Surface-to-Air Missiles* section.

### SPECIFICATIONS

#### Rapier launcher

WEIGHT	1227 kg
LENGTH	4.064 m
WIDTH	1.765 m
HEIGHT	2.134 m

#### Optical tracker

WEIGHT DEPLOYED	119 kg
HEIGHT	1.549 m
TRIPOD DIAMETER	1.828 m

#### Tactical control unit

WEIGHT	19 kg
LENGTH	457 cm
WIDTH	33 cm
DEPTH	24.1 cm

#### Generator

WEIGHT	243 kg
LENGTH	0.991 m
WIDTH	0.832 m
HEIGHT	0.914 m

#### Blindfire tracker

WEIGHT	1186 kg
LENGTH	4.14 m
WIDTH	1.753 m
HEIGHT TRAVELLING	2.032 m
HEIGHT DEPLOYED	3.378 m

#### Mk 1 Missile

TYPE	single stage, low altitude
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Rapier of the Royal Air Force Regiment defending a USAF F-111 base with generator on the left

LENGTH	2.24 m
DIAMETER	0.133 m
WING SPAN	0.381 m
LAUNCH WEIGHT	42.6 kg
PROPULSION	two-stage, solid propellant
GUIDANCE	semi-automatic optical command-line-of-sight, or thermal, command-line-of-sight or automatic command-line-of-sight using Blindfire radar
WARHEAD	1.4 kg HE, semi armour-piercing with crush fuze
MAX SPEED	650 m/s
MAX RANGE	7000 m
MIN RANGE	500 m (optical/Blindfire Rapier)
MAX ALTITUDE	around 3000 m
MIN ALTITUDE	less than 15 m
LAUNCHER	mobile trainable four-round trailer-mounted

**Status:** In production. In service with:

**Abu Dhabi:** This country placed its first order, then worth £35 million, late in 1974. It originally deployed an optical version but subsequently deployed Blindfire.

**Australia:** A contract for 20 optical Rapier systems was signed in December 1975, with the first optical Rapier fire unit accepted in October 1978. The contract included test equipment and a base repair facility. In January 1977 an order was placed through British Aerospace worth £13 million for 10 Blindfire radars to give the system an all-weather capability. Rapier became operational with the 16 Air Defence Regiment, Australian Army, in 1980. The Australian Government and private industry are involved in the manufacture of various Rapier equipments which include the specially designed Australian generator and the supply of optical and other components for Rapier tracker sights and fire units. The Rapier contract required that 30 per cent of the value was to be placed with Australian industry, and this was met in full. Australia now makes the rocket motor and undertakes final assembly of the missile with a complete Rapier magazine constructed at the Munitions Filling Factory at St Mary's, Sydney. The 16 Air Defence Regiment deploys 12 of the launchers with two at the RAEME School at Albury, four at the School of Artillery in Manly, Sydney and the remaining two in operational reserve.

**Brunei:** The government of Brunei announced its intention to purchase Rapier Blindfire in late 1978 with the contract, worth over £30 million, being signed in 1979 and first units delivered in 1983. Late in 1980 British Aerospace was awarded a contract worth more than £3 million by Brunei for construction of a missile firing range on its coast. It is understood that a total of 12 Rapier fire units and 4 Blindfire radars were delivered.

**Indonesia:** Late in 1984 Indonesia signed a contract worth £100 million for optical Rapier air defence systems for use by the army. The contract also covered the transfer of technology to Indonesia. A second order, valued at over \$100 million, was announced in December 1985. The third order, worth £40 million, was signed in December 1986, to bring the total to 51 optical systems. In early 1987 Indonesia became the first export customer for the British Aerospace Battery Command Post Processor System for Rapier. Total value of the contract, for five systems plus spares, was half a million pounds.

The Battery Command Post Processor, which is already used by the British armed forces, links by radio all elements of the battery. Data can be passed using tactical data entry devices coupled to existing combat radio which permits the automatic transmission of data to and from the command post. Messages can also be passed in voice to the command post radio operator who enters the data, using a keyboard, into the battery command post processor. All relevant data can be received, stored, processed and displayed on request. By rapidly speeding up management and computation tasks which have previously been carried out manually, the assessment times for deployment are much reduced.

**Iran:** The first order, placed in June 1970 and worth some £47 million, covered technical maintenance and support training. It originally deployed an optical version but subsequently deployed Blindfire. In Iran, Rapiers are manned by the air force and a total of 45 launchers to equip five batteries were originally procured, although substantially fewer are now operational due to non-availability of spare parts owing to the British Government arms embargo.

**Oman:** An order was placed in mid-1974 for 28 fire units valued, with spares and training, at \$47 million. These were delivered in 1977. Oman purchased 12 Blindfire radars in 1980. The Rapiers are operated by Nos 10 and 12 Squadrons of the Omani Air Force deploying a total of 24 launchers. The remainder are used for training and war reserve.

**Qatar:** The army ordered Rapier in 1981 and now operates 12 Rapier fire units of which 6 are equipped with Blindfire radars that were acquired as part of the original order. They are used to defend the Doha Air Base.

**Singapore:** The air force deploys the 165th Singapore Air Defence Artillery Squadron with 12 Rapier launchers, which were ordered in 1981 at a cost of \$60 million. They are used in conjunction with six Blindfire radars.

**Switzerland:** The Swiss Government formally proposed the purchase of 60 Rapier units in June 1980 at an initial cost of SFr1.2 billion (£315 million) which included £50 million for Blindfire radars which are issued on the scale of one per Rapier launcher. The order was finally placed with British Aerospace in December 1980 with a proportion of the equipment built in Switzerland shared between Government Factories and private industry. This included the licensed manufacture of missiles and other parts of the Rapier system.

F+W are responsible for final assembly of the missile and licensed manufacture of the parts, minus the motor, warhead and safety and arming unit which are subcontracted to M+FA and made under licence from Imperial Metal Industries, Royal Ordnance and Marconi Radar and Control Systems. F+W and M+FA in turn subcontract to some 14 other Swiss companies.

Firing trials of the first Swiss Rapier units were completed in the UK in 1982. The Swiss use Pinzgauer (6 x 6) 2000 kg light vehicles to tow their Rapier systems.

The Swiss Rapier systems have a number of modifications to meet their unique operational environment, including an improved acquisition and tracking capability in mountainous terrain, improved ECCM capability, PPI tactical display and Swiss IFF system.

The new target display and control system allows the operator to select automatic or manual target designation, threat assessment, effective countermeasures against electronic jamming as well as fast identification of defects in the system.

BAe has also supplied a 'special to Swiss' requirements prototype Rapier Classroom Acquisition and Tracking Trainer (RCATT) for evaluation prior to the possible purchase of a number of production standard units.

Each Swiss Army mechanised division has one battalion with 20 mm LAAGs and a second with Rapier SAM systems. The latter has an HQ battery and two Rapier batteries. A total of three Rapier battalions have been formed, all of which are militia, one French speaking and two German speaking. The 60th Rapier system was handed over on 1 May 1986.

**Turkey:** In August 1983 Turkey placed a \$146 million order for 36 Rapier launchers and 12 Blindfire radars. These were delivered between November

1983 and late 1985 and used by the air force. In mid-1985 a second contract of similar size was placed but, due to financial problems, was not implemented until December 1985. This contract also involved the co-assembly of the Rapier missile.

**United Kingdom:** Army — Three regiments are deployed by the Royal Artillery, one regiment in the UK and two at Dortmund, BAOR. It originally deployed an optical system but subsequently ordered Blindfire which is issued on a scale of one per three towed Rapier launchers. By the mid-1990s there will be only two Rapier Regiments, one in UK and one in BAOR with both of these being issued with Towed Rapier.

Royal Air Force — There are seven Royal Air Force Regiment squadrons of which four are deployed in Germany and three in the UK. It originally deployed an optical system but subsequently ordered Blindfire, which is issued on the scale of one per towed launcher. When defending an airfield, the Rapiers are normally located in a double interlocking ring so they are both in-depth and mutually supporting. They are normally positioned at pre-surveyed sites within 4 to 6 km of the airfield. To set up for optical firing a flight takes 20 minutes, for secondary radar capabilities 60 minutes, for full all-weather capability 90 minutes. The current RAF Rapier squadrons are:

No 16 Squadron, RAF Wildenrath, Germany (to be disbanded on 1 April 1991)

No 26 Squadron, RAF Laarbruch, Germany

No 27 Squadron, RAF Leuchars, Scotland

No 37 Squadron, RAF Bruggen, Germany

No 48 Squadron, RAF Lossiemouth, Scotland

No 55 Squadron, RAF Leeming, Yorkshire

No 63 Squadron, RAF Gutersloh, Germany (to be disbanded on 1 April 1991).

The RAF Regiment man four optical Rapier units deployed in Belize, as well as the systems deployed in the Falkland Islands and the Gulf region.

**United States of America:** (Turkey) — In October 1985 it was announced that the US Government had placed an order under the US European Air Defense Initiative programme for 14 Rapier launchers with 11 Blindfire systems to defend two USAF bases in Turkey, these are manned by Turkish military personnel.

(UK) — Early in 1981 it was announced that an agreement had been reached between the USAF and the British Government for the supply of 32 Rapier systems to defend seven USAF air bases in the UK. These are manned by the Royal Air Force Regiment and became operational in 1985. Each launcher has one Blindfire radar. Total value of the contract was about \$327.5 million. Of the total of 32 launchers, 28 are for operational use and 4 for training. The first Rapier fire unit was handed over in October 1983 and the same year the assembly of 200 Rapier missiles commenced at the Chemical Systems Division of United Technologies in the USA. The following Rapier squadrons are formed in 6 Wing, Royal Air Force Regiment:

No 19 Squadron, based at RAF Brize Norton will defend RAF Upper Heyford and RAF Fairford, although in 1990 it was announced that this base was to close

No 20 Squadron, based at RAF Honington, will defend RAF Alconbury and RAF Bentwaters, with RAF Woodbridge close by

No 66 Squadron, based at RAF West Raynham, will defend RAF Lakenheath and RAF Mildenhall

These three squadrons are under the operational command of the Commander-in-Chief, RAF Strike Command, acting in his NATO capacity as Commander-in-Chief, UK Air.

**Zambia:** This country was supplied with 12 optical Rapiers in 1971 to defend the country against Rhodesian air attack, but they rapidly became unserviceable.

**Manufacturer (prime):** British Aerospace (Dynamics) Limited, Six Hills Way, Stevenage, Hertfordshire SG1 2DA, UK.

Telephone: (0438) 312422

Telex: 825125/825126

## British Aerospace Rapier 2000 Low Level Surface-to-air Missile System

### Development

In November 1986 British Aerospace Stevenage was awarded a contract worth some £1.6 billion for the design, development and initial production of the Rapier 2000 air defence weapon for delivery to the British Army and Royal Air Force Regiment in the mid-1990s and beyond.

Development of Rapier 2000 (which is also known as Field Standard C or FS C) actually started in 1983 as part of the continuing Rapier improvement programme contract for the British Ministry of Defence.

While the present Rapier system is considered to be effective against the current low level air threat, a major improvement programme was thought necessary if the system was to remain effective in the 1990s and beyond.

Main improvements of Rapier 2000 over the existing system can be summarised as higher rate of fire, greater operational flexibility, new and more effective missiles, extensive built in test capability, enhanced reliability, is more robust and has a significant improvement in resistance to ECM and has protection against severe battlefield environments including NBC.

Rapier 2000 has been designed to counter low and ultra-low level air threats including fast ground attack aircraft, pop-up helicopters, RPVs and cruise missiles, under all weather conditions and in an ECM and NBC environment.





*Marconi Radar and Control Systems Blindfire 2000 tracking radar for the Rapier 2000 air defence missile system*

Main subcontractors to British Aerospace (Dynamics) include Siemens Plessey (surveillance radar), THORN EMI (proximity fuze and telemetry), Cossor (IFF), Marconi Radar and Command Systems (Blindfire tracking radar and missile safety and arming system), Keelavite (primary power supply), Racal Radar (command transmitter) and Royal Ordnance (rocket warhead).

For this contract, British Aerospace have agreed with the UK MoD an incentive pricing arrangement bound by a maximum price for the whole package. The contract, as announced in late 1986, covers an initial production order sufficient to replace two of BAOR's towed Rapier air defence batteries and three squadrons of the Royal Air Force Regiment Rapiers also deployed in Germany. It is envisaged that further orders will be placed at a later date enabling additional units to be re-equipped.

British Aerospace (Dynamics) completed the development standard (A model) system trials early in 1991 and by the middle of that year was working towards preliminary systems integration of the near production standard (B model) system required to qualify the production performance and prove the design standard.

The Rapier 2000 system production line is now being laid down and it is expected that the initial operating capability of the system with the British Army and the RAF Regiment will be 1994/1995.

#### **Description**

A typical Rapier 2000 fire unit consists of three elements, each of which is towed by a Leyland-DAF 4 ton (4 x 4) truck that also carries 15 missiles and associated stores.

Rapier 2000 can engage targets through a full 360° out to a range of 8000 m and up to an altitude of at least 3000 m.

The fire unit, or launcher trailer, has eight missiles in the ready to launch position with automatic infra-red tracking which, with manual acquisition and computerised tactical control facilities, can provide an engagement capability by day and night.

By day, an optical acquisition facility can be used to acquire and designate targets for engagement. The IR tracker, mounted between the two banks of four missiles, has a passive scanning mode which can be employed to search for, acquire and track targets by day or night.

A planar array transmitter mounted on the turntable sends secure guidance commands to the missile in flight. This provides the operator with a remote viewing system that allows him to work from a protected position.

The Siemens Plessey surveillance radar trailer can be added to provide a fully automatic engagement capability and a Marconi Command and Control Systems Blindfire radar tracker trailer to provide all-weather operations.

The Siemens Plessey 3D surveillance radar, also known as the Dagger, has a multi-beam planar array antenna providing extremely low sidelobes and good multi-target discrimination. It has a compact high power transmitter employing travelling wave tube (TWT) technology, wideband receiver unit and high speed digital processing. It rejects clutter, is resistant to ECM and protects against anti-radiation missiles. It has integral IFF equipment.

Dagger tracks large numbers of targets simultaneously while carrying out automatic identification. It can detect hovering helicopters and very small targets such as RPVs. By using modern filtering techniques it can detect small targets against heavy ground clutter. Excellent range resolution and the variable PRF help eliminate range ambiguities and mutual interference.

Dagger can detect multiple targets with their range, bearing and elevation to aid rapid acquisition by the trackers. The most important tracks are displayed on an associated tactical control unit.



*Trials firing of the British Aerospace (Dynamics) Rapier 2000 low level air defence system*

The new generation Blindfire radar gives Rapier 2000 an all-weather capability by day and night and incorporates its own missile command link with frequency management techniques being used to evade hostile ECM. This gives Rapier 2000 a dual fire capability.

The Blindfire radar has very narrow beams and low sidelobes to provide high accuracy target and missile tracking with multi-target discrimination and ultra-low level tracking capability.

It has a high power TWT transmitter, high speed real-time distributed processing and standardised processing hardware, integral command link transmitter for system dual capability (same as on fire unit) and an integral radar missile gathering unit providing all-weather operation.

In addition, there is the operator's control unit (OCU), tactical control unit (TCU) and a manual acquisition facility (MAF).

The OCU is used by the operator for controlling engagements while the TCU is used by the unit commander for combat management of the weapon system. They have controls and displays for controlling and optimising the weapon system performance in a multi-threat environment.

Both the OCU and the TCU continuously monitor the combat readiness of the system and allow access to automatic BIT (built-in-test) and fault diagnosis. As all controls are duplicated at both units, the complete system can be operated by one man from either unit.

The MAF allows targets to be acquired passively when radar transmissions are not desirable. It can also be used with the fire unit alone to provide an air defence capability during initial system deployment or in those situations where only the fire unit can be deployed.

All three elements of Rapier 2000 use a common trailer base (CTB) which is not only much stronger but is also easier to decontaminate due to its smoother shape. The CTB is supplied by British Aerospace (Dynamics) to Siemens Plessey and Marconi Radar and Control Systems who then install their respective systems into the trailer.

Each trailer also has its own integrated diesel-electric power supply, air-conditioning unit and liquid-cooled electronics unit.

The trailer interconnections incorporate fibre optics and nuclear hardened microchips that offer increased resistance to radiation and electromagnetic pulse (EMP) effects. The CTB also has a low thermal/acoustic signature for survival in ground suppression environments.

Extensive standardisation of equipment, including standard PECs, power supplies and components eases the test, repair and logistic overheads.

Rapier fires the new Mk 2 missile which replaced the earlier Mk 1 in production in 1990. Externally it is very similar to the earlier Mk 1 but all major components have been replaced or upgraded. New pyrotechnics provide a 10-year shelf-life without the requirement for interim maintenance.



*Plessey-Siemens surveillance and target acquisition radar for Rapier 2000 SAM system. It has an advanced planar array and uses the same trailer as other parts of the BAe Rapier 2000 system*

There are two versions of the Mk 2; the Mk 2A and the Mk 2B. The Mk 2A retains the semi armour-piercing warhead of the Mk 1 and is fitted with an impact fuze.

The Mk 2B has a dual purpose semi armour-piercing fragmentation warhead which is triggered by a new crush or active infra-red proximity fuze developed by THORN EMI. The Mk 2B has been designed to engage small airborne targets such as cruise missiles and RPVs.

The new missile fuze employs an infra-red laser transmitter and four quadrant receiver optics, coupled with intelligent signal processing. This determines the optimum range to the target at which to detonate the warhead.

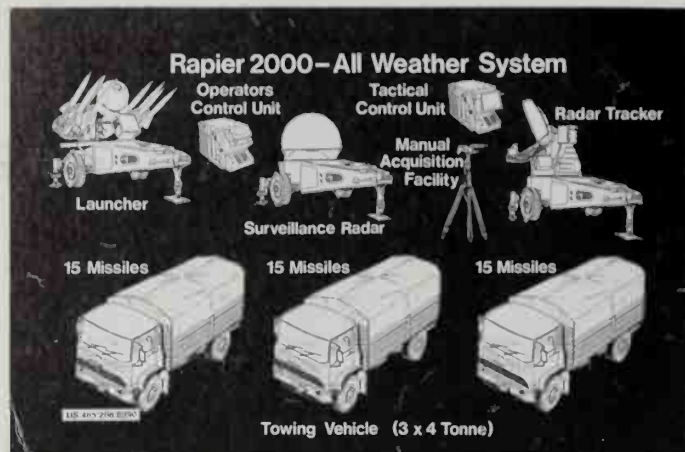
The Mk 2 missile can be fired by Rapier 2000 and most of the earlier Rapier air defence systems. It also has increased range due to the new Royal Ordnance Thermopylae two-stage elastomer modified double base propellant motor that provides a Mach 2 plus boost coast profile.

A typical Rapier 2000 target engagement would take place as follows. The surveillance radar would first detect, interrogate and form tracks on hostile aircraft.

Information describing target tracks is passed to a threat assessment algorithm which allocates the target to be engaged according to threat priorities that are defined by the customer.

Once the target has been allocated, the operator has the choice of selecting either a radar tracker or an electro-optical tracker engagement.

In the case of the former, the radar tracker is directed to acquire the highest priority target and after acquisition the target is automatically



*Block diagram of the key components of the British Aerospace (Dynamics) Rapier 2000 low level air defence system*

tracked. The operator then activates the fire button and the missile is launched. Once launched the radar gathering sensor guides the missile into the tracker beam where it is tracked differentially until target impact. The missile guidance commands are transmitted from the radar tracker command transmitter.

The missile is guided towards the target using Automatic Command-to-Line-Of-Sight (ACLOS) with the target being destroyed either by a direct hit or proximity fuze fragmentation warhead.

With the first missile in flight, the fire unit is directed to acquire the next highest priority threat and on acquisition a second missile is launched and guided towards this target using guidance commands from the command transmitter on the fire unit.

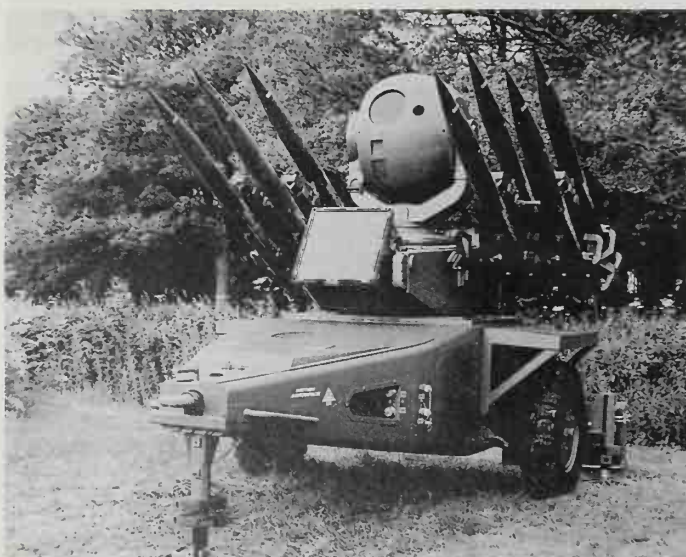
The ability of Rapier 2000 to engage two targets was demonstrated early in 1991. The first missile was launched and guided by the radar tracker against a Jindivik target and seconds later, while the first target engagement was still in progress, a second missile was launched under control of Rapier 2000s electro-optical tracker against a second target that was simulating a ground attack aircraft.

**Status:** Entering production for the British Army and Royal Air Force Regiment.

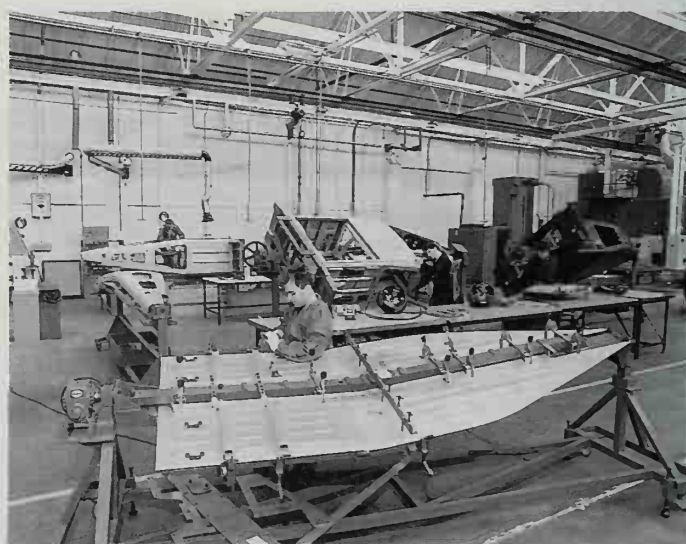
**Manufacturer (Prime):** British Aerospace (Dynamics) Limited, Six Hills Way, Stevenage, Hertfordshire SG1 2DA, UK.

Telephone: (0438) 312422

Telex: 825125/825126



*British Aerospace (Dynamics) Rapier 2000 fire unit deployed with eight Rapier Mk 2 missiles in the ready to launch position with optical tracker between banks of four missiles and planar array transmitter below optical tracker*



*Common Trailer Base (CTB) in production at British Aerospace (Dynamics) Lstock facility. This is used for all three elements of the Rapier 2000 system and is much stronger than the current trailer as well as being easier to decontaminate*



## British Aerospace Wolverine Anti-Tactical Ballistic Missile (ATBM) System

### Development/Description

The Wolverine ATBM concept is based on the use of a modified vertical launch solid propellant powered Seawolf missile with a low risk guidance system to deal with battlefield missile threats.

The highly automated guidance type under consideration for Wolverine is known as Missile Reference Command-to-Line-Of-Sight (MRCLOS) which relies principally upon an inertial reference within the weapon to keep it on course for intercepting the threat.

This minimises the command link update transmissions and allows a single fire control system to guide several missiles at once on a time-shared basis thus boosting the target-handling rate.

The MRCLOS guidance is able to cope with all current and projected upgraded versions of Soviet SRBMs such as the SS-21 Scarab and SS-1 Scud B/C/D.

The missile itself is to use a flechette type warhead and, if served by the correct radar type, could engage aircraft as well as missile targets.

A typical role for the 20 km range Wolverine could be the close area defence of an airbase using a 32-round vertical launch container, a 2D surveillance radar and an I/J-band fire control radar.

It would also be possible to network a Wolverine launch complex to the radars of a Patriot area defence system so as to provide terminal air defence of the Patriot launchers themselves against SRBM attack while they engage aircraft or missiles targeted at higher value or time urgent targets.

In 1988 the US Army Strategic Defence Command placed a contract with British Aerospace to evaluate the Wolverine ATBM using advanced seeker, warhead and fire control radar technology concepts. This work is being carried out under the US SDIO Invite, Show and Test programme for theatre missile defence systems.

Also under study is a tracked launcher with eight rounds carried in canisters. These would be raised to the vertical for missile launch.

**Status:** Concept study. Deliveries could be made within five years of a development go-ahead decision.

**Manufacturer:** British Aerospace (Dynamics) Limited, Six Hills Way, Stevenage, Hertfordshire, SG1 2DA, UK.

Telephone: (0438) 312422

Telex: 825125/825126

## Shorts Tigercat Low Altitude Surface-to-air Missile System

### Development

In the late 1950s Shorts Precision Engineering Division at Castlereagh developed the SX-A5 surface-to-air missile system using manual-command-link control. The company was awarded a development contract early in 1958 for a small SAM to provide close defence of Royal Navy warships.

The missile system was originally called Green Light but was renamed Seacat in 1959 and by 1961 acceptance trials were under way with first production missiles completed in 1962. In addition to the Royal Navy, Seacat has been purchased by at least 16 other navies all over the world. By 1987, total sales of Seacat and Tigercat systems amounted to some £650 million. The last contract was placed in the mid-1970s for prime equipment, but Shorts are still supplying missiles and spares. Together with Seacat, more than 15 000 missiles have been produced.

Although originally intended for naval applications, early consideration was given to developing a land-based version for defence of airfields and other high value targets and this was subsequently called Tigercat.

Tigercat was purchased by the Royal Air Force Regiment as its first SAM system and became fully operational in 1970. These have now been replaced by the British Aerospace Rapier.

The Tigercat SAM system has been exported to Argentina, India, Iran, Jordan, Kenya and Qatar. During the 1982 Falklands conflict both the Argentinian Army and Marine Corps deployed Tigercat systems to the area of Port Stanley. The Marine unit, the 1st Marine Anti-Aircraft Regiment, had three firing units whilst the Army unit, the 601st Anti-Aircraft Defence Group, had four. Although a number of Tigercats were fired, none scored any hits on British aircraft or helicopters. All the launchers were used in

conjunction with 20, 30 and 35 mm anti-aircraft cannon and ground radar control units. Following the Argentinian defeat, all seven firing units were apparently captured in fairly intact condition.

The systems originally sold to Jordan have found their way to South Africa, but it is understood that they are no longer operational.

### Description

A Tigercat Mk 1 SAM system consists of three main components: the missile, launcher trailer and director trailer. Each trailer is towed by a Land Rover (4 × 4) light vehicle with the system normally having a five-man crew, of whom one is the gunner. Tigercat can be operational within 15 minutes of coming to a halt.

The launcher trailer consists of a two-wheel chassis integral with a three-missile, two axes rotatable launching platform. In the firing position the trailer is supported on three outriggers. The launcher incorporates an electrohydraulic system which moves it to the correct bearing and elevation as determined by the aimer's sight.

The gunner, or aimer, is seated in the director trailer which is supported on four jacks. Attached to his seat is a structure with binoculars, firing button, thumb-operated joystick and fixed transmitting aerial for the guidance system.

The aimer acquires the target using his binocular sight and when the target comes within range the aimer starts the firing sequence which launches a missile from the three-round launcher two seconds later.

At a range of approximately 300 m the missile appears in the aimer's sight and is guided visually along the line-of-sight to the target. Fin-mounted flares ensure that the missile is visible all the way. The aimer flies the missile along the line-of-sight to the target by means of a thumb joystick.



Three-round Tigercat launcher deployed in firing position with trailer supported on three jacks and missile covers removed



Shorts Tigercat operator in director trailer



Shorts Tigercat surface-to-air missile system deployed in field with launcher on left, director in centre and Marconi ST850/M radar on right



Tigercat missile being launched showing the flare tubes in the fins which are used by the operator to track the missile (Ministry of Defence)

The guidance and control system translates the thumb joystick movements into radio commands and transmits them to the missile via an aerial on top of the three-round missile launcher.

When the missile hits or passes close to the target the contact/proximity fuze is activated.

The missile itself is a small single stage subsonic unit with a relatively large high explosive blast warhead fitted with a contact/proximity fuze. Its Imperial Metal Industries motor is the tandem type, boost and sustainer.

The missile has four movable wings swept back at an angle of 60° and four fixed fins at the rear. The fuze is mounted at the front of the missile followed by the warhead, electronic pack, control surface (wing) actuator assembly and finally the rocket motor assembly. The fixed rear fins are set at 45° to the wings to reduce downwash effect of control movements and each fin incorporates flare tubes, although only two contain tracking flares.

No pre-firing 'warm-up' sequences are required and auxiliary power services within the missile are activated at launch.

Since it was first introduced, the missile itself has been constantly updated and today's version is much more reliable and lethal than the original. According to Shorts, two Tigercat fire units would have an equal attrition rate to 12 Bofors 40 mm L/70 guns and save over 70 per cent in manpower and 90 per cent in airlift weight.

Target detection is provided either from forward observation posts to surveillance post or by a surveillance radar, and gives the gunner the direction of attack. The gunner acquires the target visually and when within range a missile is launched and guided to the target by him.

Tigercat can be integrated with fire control radar units to give dark fire or even blind fire capability for all-weather use.

The launcher takes about three minutes to be reloaded with new missiles which are provided with rigid covers for transport. The covers are removed manually once the missile has been placed on the launcher.

As far as is known only one export customer, Kenya, has the all-weather Radar Enhanced Mk 2 Tigercat version which uses the Marconi ST850/M radar with its associated TV system. The ST850/M is mounted in a fully enclosed mobile cabin and could also be integrated with the I/J-band Marconi S860 mobile surveillance radar.

The ST850/M gives Tigercat an all-weather capability as well as enhancing the clear weather performance via a TV auto-gather facility. In conditions where the missile is visible, it is automatically gathered within a few seconds of launch after which the engagement is completed automatically

or manually using the TV monitor.

The radar may assume control of either of two Tigercat units, providing fully automatic control of the channel while the second channel reverts to optical control.

The fully enclosed cabin is air-conditioned with the director mounted on the roof. This carries a 1 m diameter antenna and the TV camera and covers an elevation arc from -25° to +85°.

#### SPECIFICATIONS (missile)

TYPE	two-stage, low altitude
LENGTH	
missile	1.480 m
missile in canister	1.548 m
DIAMETER	
missile body	0.191 m
missile in canister	0.711 m
WING SPAN OF MISSILE	0.65 m
LAUNCH WEIGHT	62.7 kg
PROPULSION	dual solid fuel booster/sustainer
GUIDANCE	command-to-line-of-sight
WARHEAD	17.2 kg HE blast fragmentation with contact and proximity fuzing
MAX SPEED	Mach 0.9 approx
MAX RANGE	5500 m
MIN RANGE	300 m approx
MAX ALTITUDE	4000 m plus
MIN ALTITUDE	30 m
LAUNCHER	mobile, triple trainable mount

Status: Production of missile as required. In service with:

Country	No of launchers	Operator
Argentina	10	Army, Marine Corps
India	40	Army
Iran	15	Air Force
Kenya	not available	Air Force* (1 battery)
Qatar	5	Air Force (1 battery)

\* Note: These Kenyan missile systems were supplied in kit form in 1978, stored and not assembled and checked until early 1987. First trial firings were successfully completed from 18 to 28 May 1987.

**Manufacturer:** Short Brothers PLC, Defence Systems Division, Montgomery Road, Belfast BT6 9HN, Northern Ireland.

Telephone: (0232) 458444

Telex: 747087

Fax: (0232) 705293

## Medium Surface-to-Air Missile System (MSAM) Programme

### Development/Description

In response to the final phase-out of its Bloodhound air defence missile system on cost-effective grounds the Ministry of Defence has issued an Invitation to Tender (ITT) to industry for the RAF's MSAM or Bloodhound replacement requirement.

The ITT was preceded by a draft Cardinal Points Specification (CPS) with the final CPS being issued with the ITT documentation. If the contract is awarded then it will be let on a single prime contractor with responsibility for not only the supply of the systems but also for associated matters such as work services and integration with the Improved UK Air Defence Ground Environment (UKADGE) national command and control network.

Industry teams known to be interested in bidding for the contract include:

(a) British Aerospace (Dynamics) Ltd with Raytheon Corporation offering a



comprehensive layered system utilising the latest Patriot version and Rapier 2000 weapon systems

- (b) GEC-Marconi with EUROSAM offering the Surface-to-air Missile/Terrain (SAMP/T) medium-range SAM system
- (c) Hughes Aircraft Company with Norsk Forsvarsteknologi (NFT) and Siemens Plessey Radar offering the Advanced Surface-to-air Missile System (AdSAAMS) based on the AIM-120 AMRAAM.

## Bloodhound Mk 2 Low to High Altitude Surface-to-air Missile System

### Development

Shortly after the end of the Second World War the Royal Air Force issued a requirement for a medium/high altitude surface-to-air missile system which was subsequently given the code name Red Duster.

Prime contractor was the Bristol Aeroplane Company and after extensive trials, production of the missile commenced at Filton in 1957. This entered service with the then Royal Air Force Fighter Command as the Bloodhound Mk 1 pulse radar semi-active homing missile with the first squadron becoming operational in 1958.

Bloodhound was deployed between 1958 and 1961 at RAF Woolfox Lodge, Watton, Woodhall Spa, Dunholm Lodge and North Coates and used mainly to defend the V-bomber and Thor IRBM bases in Lincolnshire and the East Midlands.

Sales of the Bloodhound Mk 1 were also made to Australia (one squadron in 1959) and a trials quantity to Sweden in 1958, but none is now operational.

Between 1951 and 1959 over 500 test vehicles were built and delivered with a total of 300 production Bloodhound Mk 1s delivered between 1958 and February 1960.

The Bloodhound Mk 1 was followed by the Bloodhound Mk 2 on which design work commenced in 1958. This entered service in 1964 and has an improved warhead, longer range, is more effective at low level and has greater resistance to ECM.

Production of the Bloodhound Mk 2 missile was undertaken at Cardiff in South Wales and a total of 783 were built with final missiles built for Switzerland in late 1966.

Bloodhound Mk 2 is slightly longer than the Mk 1 with more powerful Thor ramjets and larger boost motors. There was also a project for the Bloodhound Mk 3, or Blue Envoy as it was also called, but this was cancelled in 1962.



Bloodhound Mk 2 immediately after launch from its Type 202 single round static launcher with power provided by the four boosters

The desire is to have an in-service date of around the mid-1990s but the project could possibly slip to the late 1990s due to the current financial situation within the UK Defence Ministry or even shelved if the UK air defence requirements as a whole suggest that such a system is not necessary.

**Status:** ITT documents were received back by the British MoD in December 1991.

The Bloodhound Mk 2, nicknamed in the RAF the 'Dog', was withdrawn from operational use on 1 July 1991. The decision was based on a re-assessment of the cost-effectiveness of the Bloodhound Force. A full description of the use of the Bloodhound in RAF service can be found in *Jane's Land-Based Air Defence 1991-92* pages 271-273.

The Bloodhound Mk 2 was phased out of service in 1974 with the Royal Swedish Air Force (which purchased it in 1964 and called it the Rb 68) and in 1990 with the Singapore Air Force (one squadron formed in 1970 as the 170th Singapore Air Defence Artillery Squadron attached to the Integrated Air Defence System (IADS) operated in conjunction with Malaysia, Australia, New Zealand and the United Kingdom with a total of 24 launchers taken over from the RAF, ex-No 65 Squadron, (originally 28 launchers) but remains in service with the Swiss Air Force (used by the Fliegerabwehr Brigade 33). The Brigade comprises the 71st Air Defence Missile Squadron (with 32 launchers) and the 72nd Air Defence Missile Squadron (with 32 launchers). The former is based in the eastern part of the country and the latter in the west. There are six Bloodhound missile sites in total, four with eight launchers and two with sixteen launchers.

The Swiss Air Force designation is BL-64. They also have two Ferranti training simulators. The remaining Swedish Bloodhound Mk 2 Missiles were purchased by Switzerland and the UK.

Early in 1984 British Aerospace was awarded a contract by Switzerland for the further supply of Bloodhound boost motors, indicating a significant continuation of the system's life.

Late in 1986 a series of firings of Bloodhound Mk 2 SAMs was carried out at the Royal Aircraft Establishment's range at Aberporth by the RAF. Under the auspices of the Swiss Air Force and BAMF (Swiss Maintenance Organisation) the Royal Air Force also supported firing trials of Bloodhound missiles taken from the Swiss weapon stock.

- The aim of these trials, which were carried out successfully, was to:
- (a) prove the continuing operational reliability of Bloodhound missiles of varying age
  - (b) check the interception by Bloodhound of air targets (radar augmented Jindivik drones) operating under different ECM conditions
  - (c) confirm the correct functioning of the Bloodhound tracker radar and weapon launch post following a recently completed equipment upgrading programme.

In 1987 British Aerospace, Naval and Electronic Systems Division, was awarded a £4 million contract from the Swiss Government to update Bloodhound SAM Launch Control Posts in conjunction with Ferranti Computer Systems.

### Description

A basic Bloodhound Mk 2 SAM section usually comprises four to eight Type 202 launchers, each with a Bloodhound Mk 2 in the ready to launch position, a Target Illuminating Radar (TIR), a Launch Control Post (LCP) caravan with its own power generator and computer air-conditioning and associated power supplies, cables and ground support equipment. Usually there is at least one reload round per launcher.

It is integrated into an overall air defence system, although it can operate independently if required by the tactical situation.

The missile is launched with the scanner pointed to the predicted target direction at the end of boost. The steering system is locked until the end of the boost phase.

The TIR searches for, acquires, then automatically tracks and illuminates the target. It also interrogates the target via IFF for positive identification and transmits the appropriate information to the LCP. When alerted for action the weapons attached to the LCP rotate in unison to point in the same direction as the TIR.

When the target is within the effective range, a Bloodhound is launched with the receiver in the missile nose detecting and following the radiation reflected by the target as it is illuminated by the TIR.

The control officer is seated in the LCP which is the control centre of the missile section. A computer in the LCP processes the output data from the TIR to determine the optimum conditions for the target engagement. The computer also performs routine tasks concerned with the state of readiness of the system and its missiles.

The LCP operators are provided with displays and communications equipment to enable rapid operational decisions to be taken and to maintain maximum equipment serviceability by displaying the combat readiness state of each of the LCP's missiles.

Once the control officer has found a 'hostile' target on the computer-generated console display and its signal-to-noise ratio has been checked for a strong enough reflected radar signal to track, the computer, given

elevation and azimuth track data, uses trigonometry to calculate the target's height. If these parameters are within engagement limits then the 'Free to Fire' statement is displayed on the control officer's console screens.

The launch button is depressed and the computer checks out each LCP Bloodhound in turn. At the first available fully serviceable missile/launcher combination found, the launch signal is sent through the two connecting cables from the LCP. The chosen assembly and missile are initially paired via signals from the TIR that are received by the tall 'Stalk Aerial' on the rear of the launcher. The boosters are fired and the bolts connecting the missile to the launcher are sheared.

No missile can be launched until both operators have turned separate keys to release the firing circuit. The control officer's master video screen also has a clock countdown to interception timer and if the reflected signal display flares and then disappears as this reaches zero, the target is considered to have been destroyed.

The TIR radar used by the Swiss AF is the Scorpion, a version of the Type 87.

The Scorpion was designed for static operations or where system mobility is not a prime consideration. It has a number of transportable units and has a larger 4.2 m diameter antenna providing a longer range of 400 km. The target range does, of course, depend on the target radar cross-section; for a typical Soviet fighter bomber a range of 200 km is more realistic.

The Scorpion is a CW Doppler system operating in the I/J-bands and is said to have good performance in the presence of natural or ECM interference. The missile is mounted on the launcher at an angle of 34° 30' and is slaved in azimuth to the TIR via offsets in the LCP.

The TIR can also converse with the missile in flight passing guidance commands together with an identifying reference signal so that the weapon is not confused by the control or search activities of other TIRs. A target using jamming techniques can also be tracked by locking-on to the received jamming signal. The system can also track in memory if the contact is temporarily lost.

The Bloodhound is boosted to a maximum speed of Mach 2.5 by four RO Gosling solid propellant rocket boost motors which develop 45 360 kg of thrust and burn for four seconds by which time the two Rolls-Royce Thor ramjets have reached ignition speed. The missile itself is initially accelerated from rest to 1220 km/h within a distance of 7.62 m.

As the missile rapidly builds up velocity it flies out of the ring of four expended boosters which are then discarded together with the fins; the Thor ramjets then take over to sustain it through a maximum flight time of up to 160 seconds or so.

When the boosters have been jettisoned, the central pivoting wings are unlocked and the missile becomes steerable.

When engaging low level targets it flies downwards to pick up the radiation generated by the TIR and reflected by the target, but when intercepting a target at medium or high altitude it initially cruises at a preset height (12 192 m or 15 240 m), then climbs or dives during the terminal stage to attack the target. The HE fragmentation warhead is mounted to the rear of the nose-mounted semi-active radar receiver and guidance electronics and has a THORN EMI proximity fuze. The continuous rod fragmentation warhead detonates to produce a 37 m lethal diameter circular zone full of fragmented rod pieces.

## Missile Detail

The missile is a ramjet-powered monoplane with moving wings. It is boosted to supersonic speed by four solid boost motors with fins that are linked to a common thrust ring and discarded when the missile has achieved operational speed.

The missile manoeuvres by means of twist and steer in the same way as a bird in flight. A twist and steer missile rolls so as to align to normal to the wings with the vector direction in which the manoeuvre is required and then pitches in that direction to complete the manoeuvre. The wings rotate together to produce pitch manoeuvres and in opposite directions to produce roll.

The missile homes onto a target following a proportional navigation course (a line-of-sight to the target is maintained by the missile's receiving aerial, whilst the axis of the missile is aligned towards the predicted interception point). The rate of turn of the missile is therefore proportional to the rate of change of sight-line angle.

Throughout the flight, the missile's guidance takes into account variables such as missile altitude, target course and speed, and variation in the reflected signal from the target. A gyro is employed as a space reference to determine dish position.

Error signals proportional to the difference between gyro and dish orientation are used to operate hydraulic valves which control a pair of double acting jacks; these in turn position the dish in pitch and yaw. At the same time more powerful hydraulic servos are energised in order to position the wings to steer the missile. The required pitch and yaw components are compared to obtain a roll signal, and the required pitch signal is passed to the wing servos while the missile rolls to the required altitude. A feedback circuit ensures that, in the absence of any guidance demand, the missile remains stabilised.

The missile has five main units: forebody, mainbody, ramjet engines, boost motors and control surfaces.

The Type 202 zero length launcher has three main functions: first to support the missile at the firing elevation, secondly to provide or route all the necessary facilities to the missile in preparation for firing and thirdly to turn the missile to the correct launch bearing. In order to perform these functions the launcher has an electronic power supply and hydraulic pack that rotates the launcher and powers the missile's controls during the first few seconds of the launch sequence and flight. A dehumidification system also maintains a supply of dry air to the electronics bays. The launcher can rotate through 540° during tracking.

The missile is supported on the launcher beam at the front end of the boosts and at the rear end of the missile mainbody. The rear connection is made through shear pins which are broken at launch under the force generated by the boosts.

## SPECIFICATIONS (missile)

TYPE	two-stage, low to high altitude
LENGTH	8.46 m (including boosters)
DIAMETER OF MISSILE	0.546 m
MAX SPAN	2.83 m
LAUNCH WEIGHT	2270 kg
PROPULSION	four disposable solid-fuel RO Gosling boosters with paired set of Thor ramjet liquid kerosene fuelled sustainers
GUIDANCE	continuous-wave semi-active radar homing
WARHEAD	HE continuous rod fragmentation
MAX SPEED	Mach 2.5
MAX RANGE	160 km
MIN RANGE	est 5 km
MAX ALTITUDE	17 000 m
MIN ALTITUDE	50 m
LAUNCHER	single rail semi-fixed or mobile trainable ground mount
RELOAD TIME	20 mins

**Status:** Production complete. In service with Switzerland.

**Manufacturers:** Prime contractor: British Aerospace (Dynamics) Limited, PO Box 5, Filton, Bristol BS12 7QW, UK.  
Telephone: (0272) 693831



*Bloodhound Mk 2 SAM deployed on its Type 202 launcher and showing the Tall Stalk Aerial on the launcher rear which receives the pre-launch signals from the TIR*



## UNITED STATES OF AMERICA

### Raytheon MIM-23 HAWK Low to Medium Altitude Surface-to-air Missile System

#### Development

The HAWK (Homing All the Way Killer) semi-active radar seeking medium-range SAM system commenced development in 1952 with the US Army awarding a full-scale development contract to Raytheon for the missile in July 1954 and Northrop providing the launcher and ground equipment.

The first guided test firing took place in June 1956 with its development phase completed in July 1957. Initial Operational Capability (IOC) of the Basic HAWK, MIM-23A, took place in August 1960 when the first US Army battalion was activated. In 1959 a NATO Memorandum of Understanding (MoU) was signed for NATO HAWK between France, Italy, the Netherlands, Belgium, Germany and the United States for co-production of the system in Europe. In addition, special grant aid arrangements were made to deliver European-built systems to Spain, Greece and Denmark and direct sale arrangements of US-built systems were made with Japan, Israel and Sweden. The Japanese sale soon expanded into a country-to-country co-production agreement with production initiated in 1968. In the same region, the United States also made grant aid deliveries of HAWK to Taiwan and South Korea.

However, in order to counter advanced threats, especially at low altitude, in 1964 the US Army initiated a modernisation programme known as the HAWK/HIP (HAWK Improvement Program). This involved a number of changes to the basic system, of which the most important were the addition of a central information co-ordinator with a digital automatic data processor at the battery HQ for target processing, threat ordering and target intercept evaluation, and updating of the missile to the Improved HAWK, MIM-23B, configuration with a larger warhead (54 kg versus 45 kg), an improved small guidance package and a higher performance rocket motor. The system modifications allowed both the missile and its continuous wave (CW) illuminating radar to discriminate a target from ground-clutter by using its velocity, ensuring low altitude coverage. Type classified in 1971, all US Army and Marine Corps HAWK battalions were subsequently retrofitted to the I-HAWK standard by 1978 and in 1974 the enlarged NATO HAWK Production and Logistics Organisation (NHPLO), including Greece which joined in 1972 but excluding Norway (which joined in 1986), Denmark (which joined in 1976) and Belgium (which eventually rejoined in 1979), awarded Raytheon a contract for co-production of I-HAWK components in Europe under the HAWK European Limited Improvement Programme auspices. This improvement programme was carried out from 1974-82. Japan followed suit with an I-HAWK co-production agreement in 1977.

In 1973 the US armed forces started a second modernisation effort under the designation HAWK-PIP (Product Improvement Program). This involved three phases, the PIP Phase I being fielded with the US forces in 1981, and included an Acquisition Radar (CWAR) transmitter to double the output power and increase detection range, the addition of digital Moving Target Indication (MTI) to the Pulse Acquisition Radar (PAR) and the inclusion of Army Tactical Data Link (ATDL) communications within the system.

The Phase II upgrade modification developments started in 1978 were used to equip the first unit in 1983. These greatly improved the reliability of the High Powered Illumination (HPI) radar by replacing vacuum-tube circuits with modern solid-state technology and added the Tracking Adjunct System (TAS) optical tracking system for operation in an ECM environment to the HPI, the Battery Control Central (BCC) and the Platoon Command Post (PCP).

The HAWK Phase II system is deployed in two basic configurations: a battery with two fire sections and an Assault Fire Platoon (AFP) with one

fire section. A third configuration is the TRIAD battery which is a combination of the two, a Battery with one fire section and two AFPs.

The standard Phase II battery consists of a BCC (TSW-12), ICC (MSQ-110), PAR (MPQ-50), CWAR (MPQ-55), ROR (MPQ-51) and two fire sections, each consisting of an HPI (MPQ-57) and three launchers (M-192). An AFP consists of a PCP (MSW-18), CWAR (MPQ-55), HPI (MPQ-57) and three launchers (M-192). The US Army has reconfigured all of their HAWK units to AFPs. However, a number of other countries still retain a battery configuration.

Belgium, Denmark, France, Italy, Greece, the Netherlands and Germany have implemented Phase I and are currently embodying Phase II. Other countries are following suit.

The complete German Air Force Air Defence SAM Order of Battle for the 1990s, under the Luftflotte HQ at Köln, is as follows:

#### 2 Luftwaffendivision, Birkenfeld

FlaRakKdo 4, Lich	
Geschwader	
FlaRakG 21, Möhnesee	(Patriot)
FlaRakG 38, Burbach	(I-HAWK)
Gruppe	
FlaRakGrp 42, Schöneck	(Shelter Roland)

FlaRakKdo 5, Erding	
Geschwader	
FlaRakG 23, Manching	(Patriot)
FlaRakG 32, Freising	(I-HAWK)
FlaRakG 34, Rottenburg	(I-HAWK)

FlaRakKdo 6, Lenggries	
Geschwader	
FlaRakG 22, Penzing	(Patriot)
FlaRakG 33, Lenggries	(I-HAWK)
Gruppe	
FlaRakGrp 43, Leipheim	(Shelter Roland)

#### 4 Luftwaffendivision, Aurich

FlaRakKdo 1, Heide	
Geschwader	
FlaRakG 26, Heide	(Patriot)
FlaRakG 39, Eckernförde	(I-HAWK)
Staffel	
FlaRasStff 144, Alt Duvenstedt	(Shelter Roland)

FlaRakKdo 2, Bremervörde	
Geschwader	
FlaRakG 24, Delmenhorst	(Patriot)
FlaRakG 36, Bremervörde	(I-HAWK)
FlaRakG 37, Cuxhaven	(I-HAWK)

FlaRakKdo 3, Oldenburg	
Geschwader	
FlaRakG 25, Eydelstedt	(Patriot)
FlaRakG 31, Westertimke	(I-HAWK)
FlaRakG 35, Delmenhorst	(I-HAWK)
Gruppe	
FlaRakGrp 41, Wangerland	(Shelter Roland)

**\*Note:** Basing deployments is subject to change because of reunification. Two I-HAWK/Patriot units will be deployed to sites in the former East Germany under the command of the 5 Luftwaffendivision. These units will replace the last two operational SA-5 complexes. The remaining structure is also to be changed.

The Danish I-HAWKS are used by the Luftvärnsgruppen (Air Defence Group of Tactical Air Command) which has eight units: Eskadrille (Squadron) ESK 531-534 and ESK 541-544 deployed on Sjælland (four squadrons protecting Copenhagen), Fyn (two squadrons of leased US Army I-HAWK systems) and at the airbases of Karup (one squadron) and Skrydstrup (one squadron).

In 1991 the Danes deployed an indigenous video tracking system for its I-HAWKS. The system utilises two optical sensors mounted with the fire control system for long-range (40 000 m) tracking and short-range (20 000 m) search functions. Depending upon the tactical situation the system is designed to switch between the optical and radar modes or use a combination. Thus the HPI can be left off until immediately before firing as the search and track phase can be totally passive.

The Phase III upgrade programme, which started development in 1981 and is currently in production for the US armed forces with deployment



Improved HAWK air defence missile site of the US Army in Germany showing the four missile launchers deployed in the foreground



*I-HAWK missile leaves its three-round M192 launcher during US test in April 1988 on Patriot/HAWK interoperability trials*



*Three-round I-HAWK M192 missile launcher deployed in the field*

started in 1989, makes major modifications to many of the system's major items. The Range Only Radar (ROR) and Information Co-ordination Center (ICC) have been deleted from the system and the BCC replaced by a Battery Command Post (BCP). Major electronic modifications, which included the addition of distributed micro-computers and greatly improved computer software, were made to the BCP, PCP, CWAR and HPI.

However, the major system operational change made by Phase III is the addition of a single scan target detection capability and a low altitude simultaneous HAWK engagement (LASHE) system to the HPI by employing a fan beam antenna to provide a wide angle, low altitude illumination pattern to allow multiple engagements against saturation raids.

The US Government conducted a Missile Reliability Restoration (MRR) programme between 1982-84. Concurrent with the MRR programme, ECCM improvements were incorporated into MIM-23C and MIM-23E updated versions of the HAWK missile to counter specific ECM threats. A subsequent modification to improve performance for low altitude engagements in high clutter was incorporated into the MIM-23G model in 1990.

The most recent change to the missile modified the warhead and fuzing circuit to improve performance against Tactical Ballistic Missiles (TBMs). The modifications are believed to include altering the fuze system to react against both TBM and air-breathing targets and replacing the current generation 30 grain warhead with a 540 grain one. This missile, which will probably be designated MIM-23K, has been approved for production by the US Army. A warhead kill of a TBM target was achieved during test firings at the White Sands Missile Range during May 1991, after being cued by Patriot acquisition data. Two missiles were fired during the test, the first intercepting the target as a direct hit and the second providing a warhead kill.

Raytheon completed development of the HAWK Advanced Training Simulators (HATS) in 1991. The HATS system is designed as a cost-

effective alternative to in-field training with actual tactical hardware and provides realistic hands-on training on up to 90 per cent of the critical tasks associated with the HAWK system.

The HATS provides three-dimensional computer-aided mock-ups of the PCP, HPI and CWAR, so as to furnish training for HAWK operators, officers and maintenance personnel. The simulators closely duplicate the operational 'feel' of the tactical hardware and includes all controls, displays, test points and adjustments that are required for training of the operator and maintenance personnel. Maintenance training capability includes adjustments, various test procedures, troubleshooting and module removal and replacement. The operator training utilises authentic air defence scenarios, which replicate the Integral Operator Trainer built into the PCP.

The Phase III HAWK System will be fielded in three configurations: an Assault Fire Platoon (AFP), an Assault Fire Platoon Plus (AFP+) and a Battery. The AFP will consist of a CWAR, PCP and HPI and four launchers. The AFP+ has the same complement as the AFP with a PAR added. The Battery has a CWAR, PAR, BCP, two HPIs and six launchers. The US Marine Corps battery will be the same except it will only have four M192 launchers.

A minimum HAWK force of 19 batteries (65 AFU or AFPs) will remain under US Army control in the field indefinitely with other battalions being transferred to the US National Guard by the mid-1990s.

The full list of US Army I-HAWK battalions is as follows:

Unit	Location	Parent ADA Brigade	Unit Status
1-1st	Spangdahlen, Germany	108th	active
4-1st	Neubueke, Germany	94th	active
3-52nd	Wildflecken, Germany	10th	active
6-52nd	Wurzburg, Germany	69th	active
3-1st	Fort Hood, Texas	31st	active
1-52nd	Fort Lewis, Washington	35th	active
2-52nd	Fort Bragg, North Carolina	11th	active
2-174th	Athens, Ohio	263rd	ANG
7-200th	Rio Rancho, New Mexico	111th	ANG
1-263rd	(due to be operational by 1991)	263rd	ANG
2-265th	Orlando, Florida	164th	ANG

The equivalent list of US Marine Corps Light Anti-Aircraft Missile (LAAM) I-HAWK battalions (each equating to four I-HAWK batteries) is as follows:

LAAM Bn	Continental USA location	Parent Marine Air Wing	Unit Status
3rd	Cherry Point, North Carolina	2nd	active
2nd	El Toro, California	3rd	active
4th	Fresno, California	4th	reserve

During Operations Desert Storm/Desert Shield US forces deployed 24 HAWK fire units to the Gulf region.

Norway has developed its own HAWK upgrade scheme known as the Norwegian Adapted HAWK (NOAH, qv entry under Norway this section) which involved the lease of I-HAWK launchers, HPI radars and missile loaders from the USA and their integration with Hughes-Kongsberg Vaapenfabrik (HKV) Acquisition Radar and Control Systems (ARCS) in place of the normal search, acquisition and ranging radars. The ARCS is a combination of the Hughes 3D TPQ-36A Low Altitude Surveillance Radar



*US Army personnel setting up their AN/MPQ-50 Improved Pulse Acquisition radar set*





Close up of the Northrop Corporation's Tracking Adjunct System (TAS) which is mounted on top of the HAWK's HPI radar system (of which a second unit is seen behind the gunner)

(LASR) and the NFT Fire Direction Centre. A passive infra-red acquisition and tracking system is also in use. A total of six batteries was procured from 1987 onwards for airfield defence at Bodø, Andøya, Bardufoss, Evenes, Ørland and Vårnes.

During the early 1970s to early 1980s, the I-HAWK system was also sold to a number of countries in the Middle and Far East. To maintain their HAWK system's viability, the Israelis have upgraded it to the PIP Phase II standard with the addition in the mid-1970s of a Super Eye electro-optical TV system for detection of aircraft at 30 to 40 km and identification at 17 to 25 km. They have also modified their I-HAWK systems for use at altitudes up to 24 384 m and used one from an Israeli Air Force battery located in southern Lebanon to shoot down on 31 August 1982 a Syrian Air Force MiG-25R 'Foxbat-B' photo-reconnaissance aircraft flying at Mach 2.5 on a high level 21 336 m plus sortie near Jounieh, north of Beirut.

Not surprisingly, Israel was also the first country to use the Basic-HAWK in combat when, during the 1967 June war, it had destroyed one of its own Dassault Mystère IVA fighters with an incapacitated pilot on board to prevent it crashing into the nuclear weapons facility at Dimona. They followed this by the first true combat launch on 24 May 1969, when an Egyptian MiG-21 flying near Kantara, over the Suez canal, was hit at about 6700 m altitude. By the end of the War of Attrition in August 1970, Basic-HAWK had accounted for 12 Egyptian aircraft (one Ilyushin IL-28 Beagle, four Sukhoi Su-7 Fitters, four MiG-17 'Frescoes' and three MiG-21 'Fishbeds').

During the 1973 Yom Kippur War around 75 HAWK rounds were used against Syrian, Iraqi, Libyan and Egyptian aircraft and destroyed four MiG-17s, one MiG-21, three Sukhoi Su-7s, one Hawker Hunter, one Dassault Mirage V and two Mil Mi-8 helicopters. Included amongst the kills were several multiples using just one missile.

Its next use by the Israelis was in its modified I-HAWK configuration during the June 1982 Peace for Galilee war when a Syrian MiG-23 was destroyed. This was followed by the MiG-25 incident.

By March 1989 Israeli Air Force missile units had shot down 42 Arab aircraft by Basic HAWK, Improved HAWK and Chaparral SAMs.

However, before the last two Israeli uses, Iran's armed forces used I-HAWKs against the Iraqi Air Force on several occasions. In 1974 Iran supported the Kurds in a rebellion against Iraq using HAWKs to shoot down most of the 18 planes claimed by the Kurds and then, on 14 and 15 December 1974, destroyed two Iraqi fighters on armed reconnaissance missions over Iran. Following the 1980 invasion and up to the end of the war Iran is believed to have shot down at least 40 aircraft with the weapon.

Singapore operates the I-HAWK with its Air Force's 163rd Singapore Air Defence Artillery Squadron. In May 1990 two batteries of this six battery squadron were reassigned to the Integrated Air Defence System (IADS) of



M35 (6 x 6) trucks towing M192 HAWK launchers (US Army)

the Five Power Defence Agreement (FPDA) with Australia, Malaysia, New Zealand and the United Kingdom to replace Singapore's Bloodhound squadron.

The latest combat user of the I-HAWK is France which deployed one battery to Chad to defend the capital, N'Djamena. On 7 September 1987 it shot down a Libyan Air Force Tupolev Tu-22 Blinder bomber which was trying to bomb the airport.

Among the HAWK items designed and developed by Northrop are the loader/transporter, crane attachment, ramps, winter kits, hoisting beam, hoist adaptor, track cleats, wings/elevons, actuator and the tracking adjunct system.

By 1990 Northrop had built some 750 loader/transporters, 1700 three-round launchers, 38 000 sets of wings/elevons, 38 000 actuators and over 300 tracking adjunct systems with production continuing.

### Patriot/HAWK Interoperability

Patriot/HAWK interoperability has been developed and fielded to gain the benefits of effective Air Defence co-ordination when these two systems occupy the same defence area. With the introduction of Patriot's Post Deployment Build-2 (PDB-2) software, an enhance interoperability function was provided which allowed air defence commanders the ability to task organise HAWK and Patriot Fire Units under the control of the Patriot Information Co-ordination Central (ICC). The interoperability functions of the ICC software have been further expanded in PDB-3 to provide improved capabilities in terms of Patriot/HAWK operations as well as Master Battalion enhancements. Overall, the ICC software has been automated to the maximum extent possible to complete HAWK related tasks of target identification, threat assessment and target assignments. The PDB-3 software also accommodates the HAWK Phase III improvements of passive target identification, increased update rates and improved HPI search patterns.

A major improvement of the PDB-3 software is the new Master Battalion capability. This enhancement provides the Patriot ICC with the ability to function as a Brigade and to control HAWK battalions as well as subordinate Patriot battalions. The ICC software has been programmed to threat prioritise targets and assign the most cost-effective missile system to engage the target. In May 1991 test the Patriot ICC demonstrated the capability to designate TBM targets to the HAWK system for engagement.

### US Marine Corps TPS-59/HAWK Anti-TBM Capability

During the US Army May 1991 Patriot/HAWK testing the US Marine Corps successfully investigated the use of a modified General Electric (GE) AN/TPS-59 tactical long radar system to perform the anti-TBM search and track functions for a HAWK fire control unit. No actual firing took place.

The radar was modified by GE and Sensis Corporation to allow it to track TBM targets by expanding its 3D surveillance coverage to a higher elevation, extending its range and adding a Sensis multi-scan correlator to reduce clutter and eliminate false targets. An unmodified AN/TPS-59 has a maximum altitude limit of 30 480 m and a range of 556 km. The HAWK missile was also upgraded by modifying its fuzing system and warhead to the MIM-23K standard.

If the US Marine Corps decides to enter a radar modification programme then it could issue a request to industry sometime during FY92.

### HAWK Mobility, Survivability and Enhancement (HMSE) Programme

For further development and exploitation of the HAWK system and its evolution into a system for the early 2000s, the first step foreseen by the





Raytheon designed and produced Multi-Role Survivable Radar (MRSR) and HAWK missile



HAWK tracked loader, loading three missiles onto M192 HAWK launcher (US Army)

manufacturer is the \$40 million HMSE programme. The goal of this 1995 deployment date programme by the US Army/Marine Corps and the Netherlands is to improve the system's overall mobility and reduce both the emplacement and march order times. Full-scale development started in 1989.

There are four major features of this upgrade. First, the launcher will be modified to remove its remaining vacuum-tube circuits and replace them with a modern digital laptop micro-computer. This change permits improved computation of missile launch obstruction avoidance and provides full-duplex serial data link communications between each launcher and the PCP. This last change replaces the current large, heavy, multi-conductor data cables with a telephone type field wire interconnector to the PCP.

Secondly, mechanical modifications will be made to the launcher to allow it to move during road march, with three ready to fire HAWK missiles mounted in place. The change greatly reduces launcher emplacement and march order times by eliminating the requirement to load missiles during emplacement and remove missiles during march order.

Thirdly, an upgrade to Launcher Hydraulics will be made to minimise electrical power requirements and convert the hydraulics from a fully active motor-pump design to a stored energy system employing rechargeable accumulators. The modifications will improve reliability by eliminating or replacing existing high failure rated items and the hydraulic heat exchangers. The elimination of the present motor pump and the incorporation of current generation low leakage servo valves allowed for the removal of the heat exchanger and both elevation pressure reduction circuits so providing a reduction in required prime power by a factor of six. Acoustic and IR signatures are also minimised with the hydraulic modifications.

In addition, a modification has been made to the new 5 ton Missile Loader Transport (MLT). This modification involves transporting the M501E1 tracked missile loader with three missiles and consists of modifying and reinforcing the present ramp set to support the loader with missiles during loading and off-loading operations and to provide tie down equipment for road march.

The fourth modification is the incorporation of a North Finding System (NFS) into the system. This device contains a north seeking gyroscope and a digital computer. When mounted on a HAWK radar or launcher, the NFS can provide rapid determination of the unit's azimuth alignment with respect to the true north reference. With this device, each unit of the HAWK system can be independently and accurately aligned day or night in all weather conditions without using the existing optical telescope and the need for line-of-sight between units.

Operational benefits of the mobility enhancement programme are said to be a 50 per cent reduction in HAWK prime movers and towed loads (that is, from 14 to 7 per AFP), a 50 per cent reduction in pre-siting time (from 60 to 30 minutes), a 61 per cent reduction in emplacement time (from 40 to 15.5 minutes), a 67 per cent reduction in March Order Time (from 30 to 10 minutes), a 120 per cent increase in Launcher Electronics Reliability (from 411 to 906 hours MTBF), a 67 per cent reduction in Launcher Electronics Maintenance (18 to 6 hours per year per Launcher) and a 28 per cent reduction in C-141B Starlifter sorties per AFP (from 7 to 5). Also, digital electronics includes a 'small missile' get-ready capability in preparation for the possible later addition of either AMRAAM or Sparrow missile to the HAWK launcher.

The installation of a Phase III digital computer to the launcher electronics also allows a greater dispersion of the major AFP items from 110 m apart to 2000 m, thus significantly enhancing survivability.

### Agile Continuous Wave Acquisition Radar (ACWAR)/Multiple Role Survivable Radar (MRSR)

The next change is expected to be the introduction of Agile CW Acquisition Radar (ACWAR).

The agile continuous wave acquisition radar (ACWAR) is an evolution of the HAWK CW radar technology. It performs full 3D target acquisition over a 360° azimuth sector and large elevation angles.

The ACWAR programme was initiated to meet increasingly severe tactical air defence requirements, and the equipment is designed for operation in the 1990s and the 21st century. ACWAR replaces two current HAWK radars to reduce vehicle, manpower and logistics needs. At the same time, the system provides full 3D track information on a large number of targets to accuracies sufficient for cueing and control of other remote weapons as well as data netting. ACWAR is mobile, helicopter and C-130 transportable, and can be vehicle- or trailer-mounted.

ACWAR consists of all solid-state exciter/transmitter, all digital radar control, row board transmit and receive antenna construction for precise sidelobe control, mechanical steering in azimuth and electronic steering in elevation. ACWAR uses a CW frequency-agile, phase-coded waveform. Digitised target data is sent from the radar to the HAWK PCP or equivalent. The antenna assembly is mast-mounted with a hydraulic arm elevation system.

ACWAR technologies are being used in the US Army/Raytheon Multiple Role Survivable Radar (MRSR) Program. Major purposes of this advanced development programme include survivability from anti-radiation missiles (ARMs) without decoys or EMCON, robust ECM performance against the increasing threat while continuously providing an accurate 3D air picture. It has an MTBF of over 350 hours and an MTR of 0.6 hours resulting in an availability of 97 per cent. It has the processing capability to track over 100 targets simultaneously.

### Description

The I-HAWK missile is a certified round requiring no field maintenance or testing. The certification is maintained through periodic batch acceptance testing, annual service firing and periodic batch sampling at special maintenance facilities operated by the contractor.

It is of the single stage cruciform configuration type with a dual-thrust Aerojet M112 solid propellant rocket motor, flight control is achieved by elevons located on the trailing edges of the four rear fins.

A typical I-HAWK battery engagement occurs in the following sequence.

Detection of the target happens when the acquisition radar beam returns match the required parameters of the automatic electronic data processor in the battery information co-ordination central unit. The target then becomes eligible for automatic threat ordering.

For medium to high altitude target detection the radar used is the AN/MPQ-50 pulse-acquisition set. This also has several advanced electronic counter-countermeasures (ECCM) receivers to overcome specific types of jammers. An off-the-air tuning capability also permits frequency changes to avoid enemy jamming.

For low altitude targets coverage is provided by an AN/MPQ-55 or AN/MPQ-62 (Phase I or Phase II) improved continuous-wave radar operating in alternate continuous-wave and frequency modulation/continuous-wave modes in order to provide range rate and range data. The two radars are synchronised at a scan rate of 20 rpm with the frequency modulation applied at a rate asynchronous to the scan rate so as to prevent any possibility of a dead coverage situation occurring on successive scans.

The data processor correlates with the IFF transponder returns to identify the accepted target as either friendly or hostile. If it is the latter the processor directs one of the battery's available fire units to engage the target.

The units associated high-power illuminator is slewed to the correct azimuth and automatically commanded to actively seek a designated elevation sector for the target. Once detected the radar locks-on to the reflected electromagnetic energy from the aircraft and begins to track in radial speed and angular position.



The illuminator operates with both continuous-wave low altitude and sector search capabilities and tracks the target throughout the air defence engagement cycle.

If the illuminator is not able to obtain the target's range because of enemy countermeasures then the AN/MPQ-51 range-only radar is activated. This is maintained in an operational state during the engagement by being placed in a receive-only mode with its control system continually scanning its tunable bandwidth region for the presence of jamming. It can be called into operation either automatically by the illuminator or by manual means and will transmit on a non-jammed area of its bandwidth to obtain the required target range data.

The target information is transmitted to the selected launcher assembly for the engagement. This slews to the same azimuth and elevation angle used by the illuminator and provides the power to activate the missile gyros, electronics and hydraulic systems. Once this sequence happens and the gyros are up to speed, a lead angle command is sent from the data processor via the illuminator to the launcher. The missile seeker is then space stabilised and the launcher unit realigns itself to take into account the lead angle value. On completion of the realignment the motor ignition sequence is started and the missile is fired.

The missile uses a proportional navigation collision course trajectory with in-flight guidance commands generated by the semi-active radar homing inverse monopulse solid-state seeker head fitted.

At the terminal interception point a radio frequency proximity fuze with impact override is used to detonate the HE-directed fragmentation pattern warhead. This warhead type is used to specifically increase the Single Shot Kill Probability (SSKP) in multiple target situations. A facility which the Israelis exploited on several occasions during the 1973 Yom Kippur war.

Immediately after warhead detonation a target intercept evaluation is performed by the battery Tactical Control Officer using the illuminator Doppler data to determine whether or not the missile has destroyed the target, or if further missile launches are required.

The SSKP of the MIM-23B is around 0.85, whilst that of the original MIM-23A is about 0.56.

A fuller description of the various ground equipment components of the HAWK systems is:

### AN/MPQ-50 Pulse Acquisition Radar (PAR)

The PAR is the primary source of high to medium altitude aircraft detection for the battery. The C-band frequency allows the radar to perform in an all-weather environment. The radar incorporates a digital MTI to provide sensitive target detection in high clutter areas and a staggered pulse repetition rate to minimise the effects of blind speeds. The PAR also includes several ECCM features and uses off-the-air tuning of the transmitter. In the Phase III configuration the PAR is not modified.

### CW Acquisition Radar (CWAR)

Aircraft detection at the lowest flyable altitudes in the presence of heavy clutter is the primary feature the CWAR brings to HAWK. The CWAR and PAR are synchronised in azimuth for ease of target data correlation. Other features include FM ranging, built-in test equipment (BITE) and band frequencies. FM is applied on alternate scans of the CWAR to obtain target range information. During the CW scan, range rate minus range is obtained. The Automatic Data Processor (ADP) in the ICC processes this information to derive target range and range rate. This feature provides the necessary data for threat ordering of low altitude targets detected by the CWAR.

The Phase III programme makes some major modifications to the CWAR. The basic function of the CWAR as the system's low altitude acquisition sensor remains unchanged, however the transmitted waveform was changed to permit the radar to determine both target range and range rate on a single scan. A digital signal processor (DSP) using a Fast Fourier Transform (FFT) was added to digitally process target Doppler into detected target data. The DSP provides this digital data to a new micro-computer located in the CWAR. The micro-computer performs much of the CWAR target processing formerly done by the ADP in the ICC and transmits the processed target track data to the PCP/BCP in serial digital format over a field telephone wire interconnection. The full-duplex digital link eliminates the need for a large heavy multi-conductor cable between the CWAR and PCP/BCP.

### Battery Control Central (BCC)

The BCC provides the facilities for the man-to-machine interface. The tactical control officer (TCO) is in command of all the BCC operations and maintains tactical control over all engagement sequences. The TCO monitors all functions and has the authority and facilities to enable or pre-empt any engagement or to change established priorities. The tactical control assistant assists the TCO in detection, identification, evaluation and co-ordination with higher commands. The tactical control console gives these two operators the necessary target and battery status information and controls required.

The azimuth-speed operator has the sole mission of earliest possible detection of low altitude targets. The azimuth-speed indicator console, a separate radar B-scope display, provides ICWAR target data for this purpose. Targets selected for manual engagements are assigned to one of the two

fire control operators. Each operator uses the fire control console displays and controls for rapid HPI target lock, target track, missile launch and target intercept evaluation.

In the Phase III configuration the BCC is removed from the system and replaced by the BCP described below.

### Information Co-ordination Central (ICC)

The ICC is the fire control data processing and operational communications centre for the battery. It provides rapid and consistent reaction to critical targets. Automatic detection, threat ordering, the IFF followed by automatic target assignment and launch functions are provided by the ICC. The ICC contains an ADP, IFF, battery terminal equipment and communications equipment.

The ADP comprises an electronic data processor (EDP) and a data take-off unit (DTO). The DTO forms the interface between the other system equipment and EDP. With the exception of inputs from a solid-state reader and outputs to a printer, all communications with the ECP are through the DTO. The EDP is a militarised, general-purpose digital computer especially adapted to this role.

Phase III eliminates the ICC and transfers its data processing and communications functions to the Phase III PCP and BCP described below.

### Platoon Command Post (PCP)

The PCP is used as the fire control centre and command post for the AFU. It can also be used to replace an ICC. The PCP provides manual and automatic target processing, IFF, intra-unit, intra-battery and army air defence command post communications and the displays and fire control equipment for the three-man crew. It is essentially an ICC with tactical display and engagement control console, a central communications unit, status indicator panel and an automatic data processor. The tactical display and engagement control console provides the man/machine interface for the AFP. The interior of the shelter is divided into two compartments: the tactical officer, radar operator and communications operator occupy the forward compartment with the display console, status panel, power distribution panel and communications equipment; the rear compartment contains the ADP, air-conditioning unit and IFF equipment.

### Phase III Platoon Command Post (PCP)

The Phase III PCP performs most of the same functions for Phase Assault Fire Platoon (AFP) as the PCP performed for the AFU. The new PCP uses the same shelter as the original PCP and is also operated by a crew of three consisting of Tactical Officer (TO), Radar Operator (RO) and Communications Operator. Some of the original equipment is retained in the new PCP, however a large proportion is replaced by the newly designed Phase III equipment.

The interior layout of the shelter is considerably changed with the communications operator, radios, computers, IFF set and air-conditioning equipment both relocated and changed. The entire shelter interior is air-conditioned with the larger relocated air-conditioner supplying cooling for the shelter as well as all the electronic equipment. The addition of a Nuclear, Biological and Chemical (NBC) Gas-Particulate Filter Unit (GPFU) and an entryway air lock provides positive air pressurisation of the shelter for protection of the crew and equipment from NBC effects.

Phase III electronic equipment modifications replaced the ADP with modern high speed micro-computers and more densely packed memories, replaced the TO's, RO's and TAS display with two new computer-driven display systems and provided full-duplex serial digital data link communications from the PCP to both the CWAR and HPI.

The PCP features an Integral Operator Trainer (IOT) which provides an on-site capability for HAWK Operational Training. This trainer, housed within the Automatic Data Processor, provides the realistic target simulation necessary to enable all of the fire control capabilities inherent to a fire unit to be exercised. Twenty-five simulated target scenarios, including multiple, manoeuvring and ECM targets, are contained in its software memory.

When the AFP is configured as an AFP+ which includes a PAR, the PCP used is the same as before except that an additional micro-computer is placed into the digital computer rack. This additional computer capacity is used to process PAR data and interface the PAR with the PCP.

### Battery Command Post (BCP)

In Phase III battery configuration both the BCC and ICC are replaced by a single BCP. This reduces the operating crew from six personnel to the following four operators: a TO, two ROs and a Communications Operator. The physical configuration of the BCP is identical to that of the Phase III PCP described above with the exception of a Second Radar Operator's (SRO) console placed in the left corner adjacent to the Tactical Display and Engagement Control Console (TDECC) and additional micro-computers are placed into the digital computer rack.

### High Power Illuminator (HPI)

The HPI automatically acquires and tracks designated targets in azimuth, elevation and range rate. It serves as the interface unit supplying azimuth

and elevation launch angles computed by the ADP to up to three launchers. The HPI J-band energy reflected off the target is also received by the HAWK missile for guidance. A missile reference signal is transmitted directly to the missile by the HPI. Target track is continued throughout multiple flight, and after intercept HPI Doppler data is used for kill evaluation. The HPI receives target designations from the BCC and automatically searches a given sector for rapid target lock-on. The HPI incorporates ECCM and BITE.

The Phase II programme includes two major modifications to HPI. One is the addition of a wide beam transmitting antenna which is used to illuminate a much larger volume for missile guidance during use of the Low Altitude Simultaneous HAWK Engagement (LASHE) mode of operation against multiple target attacks. The second is the addition of a digital micro-computer which processes HPI target data and provides full-duplex serial digital communications between the HPI and the PCP.

The Northrop Tracking Adjunct System (TAS) used in the HAWK-PIP Phase II upgrade for the HPI radar was derived from the US Air Force's TISEO (Target Identification System, Electro-Optical) device and provides a passive tracking capability with remote real-time video presentation.

The day only TAS is designed to complement the illuminator and can be used either coincidentally with or independent of the radar line-of-sight. Manual or automatic acquisition and tracking modes, rate memory and preferential illumination are the key features of the system.

### Northrop Tracking Adjunct System (TAS)

The Northrop Corporation Electronic Systems Division TAS is the video target identification system that is installed on the HPI radar. It enhances the HAWK missile system survivability by allowing for increased passive operations in providing preferential target illumination and performing the raid count, recognition and classification as well as damage assessment tasks.

It comprises a two field-of-view closed circuit TV camera system which is mounted on a gyro-stabilised platform and enhanced by a  $\times 10$  magnification telescope.

It is currently a day only system that is being upgraded to

- (a) improve its daytime performance (in terms of increased range and haze penetration capabilities)
- (b) add an automatic target search capability
- (c) add an infra-red focal plane array for day/night usage.

The fully functional day/night system is then designated Improved TAS (ITAS). Final development of the ITAS ended in 1991 with the field demonstration and trials phase due in early 1992.

Production of TAS devices for the US Marine Corps began in 1980 and exports have been made to seven overseas I-HAWK users. By early 1991 over 500 had been produced.

### AN/MPQ-51 Range-Only Radar (ROR)

This is a K-band pulse radar that provides quick response range measurement when the other radars are denied range data by enemy countermeasures. During a tactical engagement, the radar is designated to obtain ranging information which is used in the computation of the fire command. The ROR reduces its vulnerability to jamming by transmitting only when designated. The ROR is not retained in the Phase III system.

Available data on associated HAWK/I-HAWK radar systems is as follows (all figures in km):

Target radar cross-section	Radar						
	AN/MPQ-50 PRF setting		AN/MPQ-48 CWAR mode		AN/MPQ-46 HPI box search		AN/MPQ-51
	high	low	CW	FM	low	high	
1	79	72	52	48	75	72	63
2.4	98	90	65	60	93	89	78
3	104	96	69	63	99	93	83

### M192 Launcher (LCHR)

The LCHR supports up to three ready to fire missiles and is activated only on the initiation of the fire cycle. When the fire button is activated in the BCC or PCP, several launcher functions occur simultaneously: the launcher slews to designated azimuth and elevation angles, power is supplied to activate the missile gyros, electronic and hydraulic systems, the launcher activates the missile motor and launches the missile. The launcher is equipped with electronic cut-outs and sensing circuits that allow firing in all emplacement situations.

Raytheon have completed a proof-of-principle test which demonstrated significant improvements in launcher performance, field support, survivability and field life expectation.

Based on launcher hydraulic and power leveling system modifications the following enhancements have been achieved:

- (1) prime power requirement reduction from 21.1 kW to 3.4 kW
- (2) elimination of the hydraulic heat exchanger and the launcher battle ALERT mode

(3) a considerable reduction in the launcher's battlefield infra-red and acoustic signatures

(4) a significant reduction in the time required to both raise and level the launcher as well as raise the superstructure hatch.

### Variants

#### Self-propelled HAWK

To increase the mobility of some of its Basic-HAWK batteries, the US Army at one stage fielded several self-propelled HAWK platoons.

These consisted of three tracked M727 vehicles, based on the M548 tracked cargo carrier, each carrying three ready to fire missiles and towing one piece of ground equipment. They have now been withdrawn from service. Israel is believed to have a number of these launchers still in service.

#### HAWK on Dragon Wagon

As a private venture, Raytheon developed a version of the I-HAWK mounted on the Lockheed Dragon Wagon (8  $\times$  8) high mobility vehicle. Announced in 1978. This version was not placed in production.

#### Sparrow HAWK Demonstration Programme

Another tri-service HAWK project is a system called Sparrow HAWK. It combines elements of both these Raytheon-produced missile systems. The standard M192 launcher is modified to allow nine Sparrow missiles to be placed on the same launcher in lieu of the three I-HAWKs. In January 1985 at the Naval Weapons Center, China Lake, California, a modified missile launcher was used for field demonstration tests. A HAWK fire unit manned by a US Marine Corps team successfully fired Sparrow missiles at two unmanned aircraft targets. Earlier tests on the mobility of the system were carried out at the US Marine Corps Air Station, Yuma, Arizona.

A typical reduced-manpower Sparrow HAWK Fire Unit would comprise an IPCP, an ICWAR, an HPI, two M192 launchers with I-HAWK missiles and one M192 launcher with Sparrow missiles. The Fire Unit is also able to convert a launcher in the field for either I-HAWK or Sparrow compatibility by using the solid-state digital electronic system changes in the launcher assembly.

The two missile types can be deployed concurrently within the Fire Unit either in the HPI antenna pencil beam or simultaneous target engagement modes of operation.

The HAWK missile loader and missile pallets are eliminated and replaced by truck transportation and crane loading. Five-round Sparrow or three-round I-HAWK clips are used to reduce the loading time.

If carried by a Lockheed C-130 Hercules or helicopter the M192 launcher can be loaded with either two I-HAWK or four Sparrow missiles in the operationally ready for use condition. This considerably cuts down on the time required to go-into-action at the landing site.



Nine-round Sparrow HAWK modified M192 launcher deployed in the field



**SPECIFICATIONS (missile)**

TYPE	single stage low to medium altitude
LENGTH	5.08 m
DIAMETER	0.37 m
WING SPAN	1.19 m
LAUNCH WEIGHTS	
MIM-23A	584 kg
MIM-23B	627.3 kg
PROPULSION	dual-thrust solid fuel booster-sustainer rocket motor
GUIDANCE	semi-active radar homing with proportional navigation
WARHEAD	MIM-23A 45 kg MIM-23B 54 kg both are HE-blast fragmentation with proximity and contact fuzing
MAX SPEED	Mach 2.7
MAX EFFECTIVE RANGE	
MIM-23A	
high altitude target	32 000 m
low altitude target	16 000 m
MIM-23B	
high altitude target	40 000 m
low altitude target	20 000 m
MIN EFFECTIVE RANGE	
MIM-23A	
high altitude target	2000 m
low altitude target	3500 m
MIM-23B	
high altitude target	1500 m
low altitude target	2500 m
MAX EFFECTIVE ALTITUDE	
MIM-23A	13 700 m
MIM-23B	17 700 m
MIN EFFECTIVE ALTITUDE	60 m
LAUNCHER	mobile, triple-round trainable, trailer-mounted

**Status:** Basic HAWK: production complete. A few may still be in service.

I-HAWK: in production and in service with the following countries:

Country	No of launchers	PIP/Phase	Service
Belgium	39 (3 in store)	2	Air Force (2 battalions)
Denmark	48	2	Air Force (8 batteries)
Egypt	78	2/3	Air Defence Command (13 batteries)
France	69	2	Army (3 Regiments)
Germany	216	2	Air Force (36 Squadrons)
Greece	42	2	Army (2 battalions)
Iran *	222	—	Army (37 batteries)
Israel	180	1/2	Air Force (17 battalions) ***
Italy	60	1	Army (2 regiments)
Japan	192	1/2	Army (32 batteries) ****
Jordan	56	2	Army (14 batteries)
Korea, South	168	1/2	Army (28 batteries)
Kuwait **	48	2	Air Force (6 batteries)
Netherlands *****	54	2	Air Force (9 squadrons)
Norway	54	NOAH	Air Force (6 batteries)
Portugal	6	2	Air Force (1 battery)

Country	No of launchers	PIP/Phase	Service
Saudi Arabia **	126	2	Air Force (16 including 10 Triad batteries)
Singapore	18	1	Air Force (1 squadron of 6 batteries)
Spain	24	2	Army (2 battalions)
Sweden	12	—	Army (1 battalion, known as Rb67)
Taiwan	78	1	Army (13 batteries)
UAE	30	2/3	Air Force (5 batteries)
USA ***	unknown	3	Army (11 battalions) Marine Corps (3 battalions)

**Notes**

\* Exact status of numbers in service for Iran is unknown

\*\* These countries are known to have procured AN/TSQ-73 Missile Minder fire control systems for their I-HAWK batteries.

\*\*\* To be upgraded to PIP/Phase 3 as funding permits.

\*\*\*\* The PIP/Phase 1 systems are to be upgraded to PIP/Phase 3 as funding permits.

In 1987 it was stated that the United States Army National Guard was to receive at least six HAWK battalions as part of its ongoing modernisation programme.

As of September 1990 HAWK/I-HAWK orders included more than 38 000 missiles, 111 US Army/US Marine Corps batteries, 106 NATO nation batteries and 167 batteries for FMS customers and Saudi Arabia.

Late in 1991 it was announced that the Royal Netherlands Air Force plans to relocate its eight German-based SAM squadrons to De Peel Air Base in The Netherlands. At the same time the Dutch Patriot and Improved HAWK units are to be merged into four composite squadrons.

The four Patriot and four Improved HAWK squadrons now form part of the 3rd and 5th Netherlands Missile Groups headquartered at Blomberg and Stolzenau as part of the NATO SAM belt in Germany, and will move to the Netherlands in 1994-96.

The two groups will be merged into one 900 strong group at De Peel comprised of four TRIAD (Triple Air Defence) squadrons. TRIAD integrates Patriot and I-HAWK radar and fire control assets to form a squadron with one Patriot and two Improved HAWK fire platoons and one information co-ordination centre.

**Note:** Kuwaiti batteries were captured by Iraq during August 1990 invasion. Status is uncertain but Iraq apparently did not bring systems to operational status within its air defence network during 1991 Gulf War.

**Contracts:** For European manufacture of the Improved HAWK air defence system Raytheon was systems contractor under the direction of the NATO HAWK Management Office (NHMO) in Paris, France. In the USA, Raytheon produced the missile guidance and control units and limited quantities of ground equipment, certain missile parts, final missile assembly and overhaul and conversion of the basic HAWK equipment. A Raytheon subsidiary, Raytheon European Management and Systems Company (REMSCO), oversaw major European industrial activities. NATO nations participating in the programmes are Belgium, Denmark, France, Germany, Greece, Italy, Norway and the Netherlands.

Complete system development and US Production: Raytheon Company, Missile Systems Division, Bedford, Massachusetts 01730, USA.

Telephone: 617 274 2222

Rocket motors: Aerojet General Corporation, El Monte, California, USA.

Wings and elevons: Northrop Corporation, Beverly Hills, California, USA.

Warheads: Iowa Ordnance Depot.

NATO Improved HAWK: Belgium - ACEC; France - SNPE, SODETEG,

Thompson-CFS; Germany-AEG-Telefunken, MBB;

Italy - Aeritalia, Aerochemi, Selenia, Sigme, MES, FIAR.

Japanese production: Mitsubishi Electric Corporation Toshiba.

## Raytheon MIM-104 Patriot High to Medium Altitude Air Defence (HIMAD) System

**Development**

The concept of a mobile all-weather air defence missile was started in 1961 by the US Army Missile Command (MICOM) Research and Development Directorate as the Field Army Ballistic-Missile Defence System (FABMDS), then became the Army Air Defence System-1970 (AADS-70). By 1965 the design had been specified and the missile assigned the designation XMIM-104 Surface-to-air Missile/Development (SAM-D) before project management was placed under MICOM direction. Shortly after this, in April 1966, the US Department of Defense (DoD) issued contract definition awards to Raytheon, Hughes and RCA with Raytheon receiving an advanced

missile development contract in May 1967. The first test launch occurred in February 1970 and in 1972 the engineering development programme commenced. This consisted of two phases, the first being a 9-round flight series in 1973 to test the missile systems, then a 14-round series in 1974-75 to evaluate the Track-via-Missile (TVM) guidance system concept. The success of these tests led in 1976 to the DoD initiating the Full-Scale Engineering Development phase of what was then called the MIM-104 Patriot missile system. By 1981 all the development and operational evaluation trials were complete and limited production by Raytheon had commenced. The first production systems were delivered to the US Army in June 1982 and a follow-on test and evaluation programme was conducted in 1983. This, however, uncovered a number of hardware and training problems which were subsequently resolved with Patriot undergoing a



Four-round Raytheon Patriot surface-to-air M901 missile launcher deployed in the field

further series of firings in 1984. Following the successful completion of these the US Army declared Patriot to be fully operational.

In order to keep Patriot performance effective against a changing threat the US Army has a continuous Patriot Improvement Research and Development programme under way.

The full Patriot Product Improvement Programme schedule up to the year 2000 and beyond is as follows:

Year	Features Improved/Added
1986	Fuze processor Guidance ECCM Strobe jammer engagement mode Jammer engagement (using correlation technique) mode Out-of-sector launch capability ( $\pm 80^\circ$ )
1987	Radar enhancement Phase I IFF upgrade
1988	PAC-1 deployment Interoperability Block 1 Clutter canceller Maintenance improvements Pulse Doppler discrimination capability Transmitter maintenance upgrade DLU upgrade
1989	Stand-off jammer counter capability Pulse Doppler search/track capability Interoperability Block 2 Guidance enhancement PAC-2 deployment Optical disc
1992	Out-of-sector launch capability ( $360^\circ$ )
1994	Radar enhancement Phase II EMP enhancement VHSIC WCC ARM decoy deployment Block I Improvements
1996	Missile Active/TVM seeker Extended range Launcher Remote-control launcher Radar Enhancement Phase III Dual TWT transmitter Improved S/T receiver Command, Control and Communications (C <sup>3</sup> ) JTIDS interface SINCGARS/HCS interface HIMAD C IMPS BDE ICC Identification Mk XV IFF interface NCTR
1998	Block II Improvements Radar enhancement Phase IV $360^\circ$ intercept capability Battle management Communications Discrete target identification Phase II



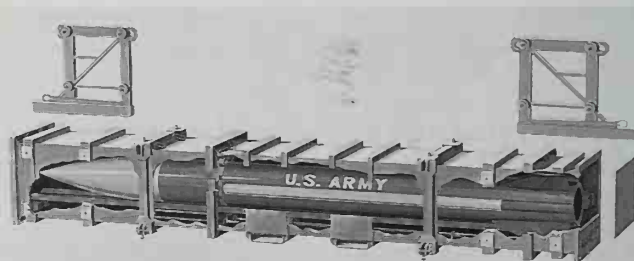
Raytheon Patriot surface-to-air missile leaves its launcher during trials

Of the features added and/or improved the following information is known.

The first, known as Phase 1B, consists of a radar enhancement design and software development for jammer engagements, guidance ECCM, a 16-missile launch capability and better battalion resource management, which was completed in 1986.

The second, Phase 1A, started in 1986 and was a radar enhancement software development by Raytheon for a Patriot out-of-sector launch capability. It was completed in 1989.

The last is the Anti-Tactical Missile (ATM) programme which consists of two parts. The Patriot Level-1 ATM (or PAC-1) requires only software changes to the ground radar itself (that is, does not require destruction of the target's warhead) for it to achieve a mission kill capability against short-range ballistic missiles such as the SS-12M 'Scaleboard', the SS-21 'Scarab' and SS-23 'Spider' by giving it an upward trajectory and a high-angle sector search capability to track them in flight. The idea is to protect the Patriot system itself. This ability was successfully demonstrated on 11 September 1986 when a modified production line Patriot intercepted a Lance missile at the White Sands Missile Range and knocked it off its intended course. The Patriot Level-2 ATM (or PAC-2) was also successfully tested at White Sands on 4 November 1987 when a suitably modified Patriot destroyed another Patriot in flight, together with its warhead, which was simulating a Soviet SRBM. The PAC-2 modification involves further software changes, a new missile warhead casing with enhanced explosives and a fuzing system with a second set of forward-angled beams designed to optimise warhead detonation against targets with a very high closing rate so as to increase sensitivity and reduce the system's reaction time. This then allows



Cutaway view of the Patriot missile sealed in its container which serves as the launch tube for the missile when it is fired. The missile's airframe and its canister are manufactured by Martin Marietta Orlando Aerospace under contract to Raytheon, who (as prime contractor) manufactures the missile's guidance and control electronics and all of the ground equipment for the missile system





*Patriot AN/MPQ-53 radar set camouflaged in its field environment*

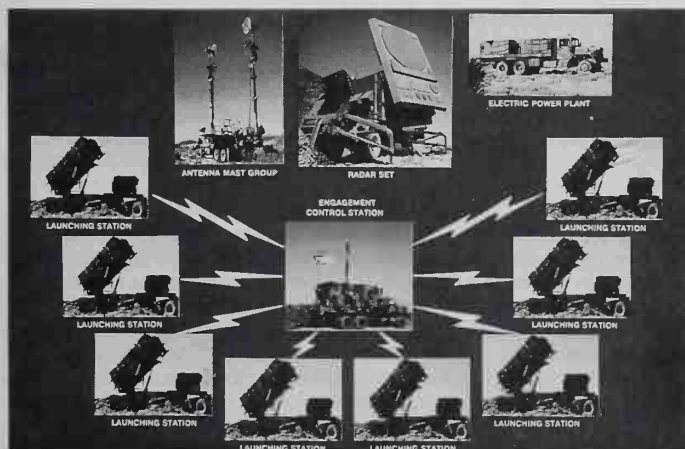
the larger 45.4 g size of the fragmentation pattern splinters produced in the explosion to perform a catastrophic kill of the target by destroying both the missile body and its warhead and is an overall improvement to system's area defence role.

The Level-1 ATM capability was deployed with the US Army in Europe in July 1988. Level-2 ATM capability deployed in August 1990 for the Desert Shield Gulf deployment. The deployment transitioned to Desert Storm with the outbreak of hostilities in January 1991. Early in the morning of 18 January (Saudi time) Patriot conducted an historic first interception of a hostile TBM threat. In all, 86 modified Scud TBMs were fired into Israeli and Saudi Arabian airspace by Iraq. Fifty-three of these were fired into Patriot defended areas, and of those 51 were intercepted by Patriot.

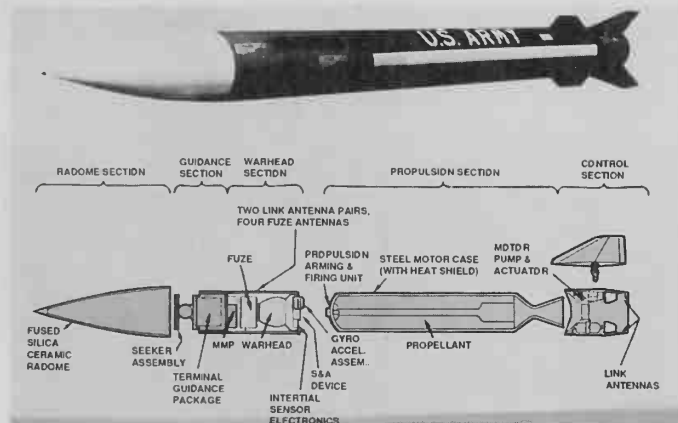
As an adjunct to the Patriot system MICOM awarded a \$2.7 million contract in May 1983 to the General Instrument Corporation's Government Systems Division to develop and build a decoy unit that could entice attacking Anti-radiation Missiles from Patriot air defence missile sites. The technological challenge in the programme was the size of the decoy which apparently became a two-manportable device. In December 1987 MICOM started seeking bids from industry to undertake a two-year Full-Scale Engineering Development (FSED) programme which involves the development, production and qualification of five decoy units. The contract will also include an option for the production of an initial 72 decoys to be built over a two-year period. Deployment is due in 1994.

In February 1989 the \$4.715 million FSED contract was awarded to Brunswick Corporation's Defense Division. The system is known as an Anti-Radiation Missile Decoy (ARM-D) and will transmit an RF signal of similar frequency and amplitude to the AN/MPQ-53 radar in order to divert the track point of the incoming threat weapon.

Under current planning, the US Army procurement objective for Patriot is 10 battalions of 60 Fire Units (seven Battalions with 42 Fire Units in Germany and three Battalions with 18 Fire Units in the Continental USA for training and so on). By mid-1989 all 10 battalions had been activated with the seven deployed to Germany as part of the 32nd Air Defense Missile Command. Currently the West European battalions have three fire units each instead of the six in their TOE. Each 600 man Patriot battalion



*The Patriot surface-to-air missile system is typically configured with eight launchers, each of which contains four missiles, plus the engagement control station, radar system, antenna mast group and the electric power plant*



*Main components of the Patriot surface-to-air missile*

comprises six batteries each of two firing platoons and four launchers. Each battery HQ and firing platoon also includes an FIM-92A Stinger manportable SAM two-man team-set of equipment for close-range low level air defence. At battalion level there is also a 6x6 truck-mounted Information Co-ordination Central (ICC) which provides battalion command and control and the interface with other air defence assets. This is performed by 6x6 truck-mounted communications relay units and attendant 6x6 truck-mounted Antenna Mast Groups (AMG).

The full list of US Army Patriot HIMAD battalions is as follows:

Unit	German Location *	Parent ADA Brigade
2-43rd	Hanau	10th
4-43rd	Giessen	10th
6-43rd	Ansbach	69th
8-43rd	Giebelstadt	69th
1-7th	Kaiserslautern	94th
4-7th	Dexheim	108th
5-7th	Bitburg	108th

Unit	Continental USA Location	Parent ADA Brigade
1-43rd	Fort Bliss, Texas	6th
2-7th	Fort Bliss, Texas	11th
3-43rd	Fort Bliss, Texas	11th

**Note:** \* Due to the Gulf deployments and the situation in Europe these locations may well be changed.

The US DoD has also promoted Patriot as a NATO follow-on system for the MIM-14 Hercules and some MIM-23 HAWK systems. In February 1979 the USA, Belgium, Denmark, France, Germany, Greece and the Netherlands signed a NATO Memorandum of Understanding (MoU) for a two year study on the most practical and economical ways to acquire and produce the Patriot system. This was itself a follow-on study to Project Successor, a joint US-German analysis, concluded in 1978, to evaluate Patriot's suitability for a European Air Defence role.

By early 1988 only two of the MoU signatories had actually procured the system. In 1984 the Netherlands ordered four squadrons totalling 20 launchers and 160 missiles. The first of these, the 502nd Anti-aircraft



*Patriot AN/MPQ-53 radar set which is built by Raytheon*



Raytheon Patriot surface-to-air missile system deployed in the field with four-round launcher (foreground), radar system (upper left) and engagement control station (upper right)

Squadron of the Royal Netherlands' Air Force 5th Guided Missile Group, became operational in April 1987 with a second squadron of the Group attaining operational status in July 1988. By 1990 the remaining two squadrons were operational with the 3rd Guided Missile Group. A follow-on order for four more fire units, 32 launchers and 256 missiles has been approved by the Dutch Government.

In 1991 the Royal Netherlands Air Force will achieve full interoperability between the two SAM groups which form the forward area SAM cluster with I (BR) Corps around Hanover, Germany.

The 5th GMG based at Stolzenau, Germany will have the two Patriot Squadrons mentioned previously, and two I-HAWK squadrons each comprising two independent Assault Fire Units (AFUs) with three M192 launchers.

The 3rd GMG based at Blomberg, Germany will have identical equipment. The total of 20 Patriot and 12 I-HAWK launchers will be supplemented by 100 Stinger missiles for short-range self-protection for the two GMGs.

The Patriot/I-HAWK squadrons will use the interoperability software developed in co-operation with Raytheon, MICOM and the Luftwaffe to allow the Patriot ICC to control both types of missile fire units.

The same operational concept is used by the GMG Netherlands that activated in the early 1990s. This comprises eight I-HAWK AFUs and the four additional Patriot fire units ordered recently for deployment at four airbases in the southern Netherlands—Colkel, De Peel, Gilze-Ruijten and the HQ at Eindhoven—for use as area defence networks over two NATO Central European rear logistic and port regions covering the Netherlands and Belgium. Late in 1991, however, it was stated all Dutch Improved HAWK and Patriot SAM systems deployed in Germany would be redeployed to the Netherlands in 1994 to 1996, additional details are given at the end of this entry.

In Europe collocation of the NATO SAM units with Army Corps areas is designed to enable better integration with the short-range air defences of the ground forces. This is being facilitated by the introduction in the early 1990s of the Mobile SAM Operation Centre (SAMOC) which will replace the current air defence liaison teams.

The SAMOC will also provide the links between the Patriot ICC and the CRCs, Sector Operation Centre and, ultimately, the relevant Allied Tactical Air Force's air defence operations centre.

In place of US 6 × 6 trucks the Netherlands uses the DAF YTZ 2300 (6 × 6) truck to tow the four-round Patriot launcher and the AN/MPQ-53 radar set, and YAZ 2300 (6 × 6) 10 000 kg trucks will carry the engagement control station.

In the same year as the Dutch ordered their systems Germany agreed to buy the system and in 1985-86 ordered the first 14 of 28 squadrons it is going to purchase and accepted, through a supplementary compensation agreement with the USA, an additional 12 squadrons are to be supplied from US Army stocks and manned by German personnel. The 40 Luftwaffe squadrons will be used to form two training squadrons, two reduced strength squadrons to act as float units and six Wings (*Geschwader*) each of six air defence squadrons (*Flugabwehr-raketenstaffeln*), one HQ squadron, a direct support unit and four radio relay groups. The major difference between this Patriot equipment and the US Army systems is that the prime German contractor, Siemens AG, is using German MAN (8 × 8) vehicles and accessories wherever possible. The first Luftwaffe firing trials were completed in November 1987 at the White Sands Missile Range using its own training equipment. The first operational units were handed over in August 1989.

The complete German Air Force Air Defence SAM Order of Battle for the 1990s, under the Luftflotte HQ at Köln, is as follows:

#### 2 Luftwaffendivision, Birkenfeld

FlaRakKdo 4, Lich	
Geschwader	
FlaRakG 21, Möhnesee	(Patriot)
FlaRakG 38, Burbach	(I-HAWK)
Gruppe	
FlaRakGrp 42, Schöneck	(Shelter Roland)

FlaRakKdo 5, Erding	
Geschwader	
FlaRakG 23, Manching	(Patriot)
FlaRakG 32, Freising	(I-HAWK)
FlaRakG 34, Rottenburg	(I-HAWK)

FlaRakKdo 6, Lenggries	
Geschwader	
FlaRakG 22, Penzing	(Patriot)
FlaRakG 33, Lenggries	(I-HAWK)
Gruppe	
FlaRakGrp 43, Leipzig	(Shelter Roland)

#### 4 Luftwaffendivision, Aurich

FlaRakKdo 1, Heide	
Geschwader	
FlaRakG 26, Heide	(Patriot)
FlaRakG 39, Eckernförde	(I-HAWK)
Staffel	
FlaRasStff 144, Alt Duvenstedt	(Shelter Roland)

FlaRakKdo 2, Bremervörde	
Geschwader	
FlaRakG 24, Delmenhorst	(Patriot)
FlaRakG 36, Bremervörde	(I-HAWK)
FlaRakG 37, Cuxhaven	(I-HAWK)

FlaRakKdo 3, Oldenburg	
Geschwader	
FlaRakG 25, Eydelstedt	(Patriot)
FlaRakG 31, Westertimke	(I-HAWK)
FlaRakG 35, Delmenhorst	(I-HAWK)
Gruppe	
FlaRakGrp 41, Wangerland	(Shelter Roland)

**Note:** Basing deployments is subject to change because of reunification. Two I-HAWK/Patriot units will be deployed to sites in the former East Germany under the command of the 5 Luftwaffendivision. These units will replace the two operational SA-5 sites. The remaining structure is also to change.

In 1984 Patriot was also selected by the Japanese Defence Agency as its long-term replacement for the Nike Hercules-J. In 1986 Mitsubishi started producing the missile under a licensed agreement from Raytheon. An initial buy of two batteries (one in knock-down form for local assembly) was made in 1985 to form training units. A total of six Japanese Air Self-Defence Force missile groups are being re-equipped at the rate of one per year between 1986 and 1991 with four batteries each of five launchers and a total of 1000 missiles (980 of which will be produced locally).

In 1987 the Italian Government after long debate decided to purchase the Patriot system. In May 1990 an initial contract was placed for ground equipment for a total of 20 Fire Units supplied via the US Army MICOMs multi-year Patriot production contract. The missiles, launchers and other equipment are to be manufactured by Italian industry under the auspices of the Italmissile consortium of SNIA-BPD, Selenia and OTO-Melara. After suitable offset agreements have been made these will enter service in the 1990s.





German Air Force 34 m telescopic antenna mast system for Patriot has been designed by Dornier and is carried on the rear of a MAN (6 × 6) truck. The vehicle is known by the designation Antennenmastanlage AMA

In return, the Italians are providing short-range air defence, including the Skyguard air defence system and the Spada surface-to-air missile system, for the protection of key US bases in Italy.

A full list of the other countries which have either expressed or are actively looking at Patriot include the UK, Greece, Spain, Switzerland and Turkey within NATO/Europe, Bahrain and the UAE in the Middle East and Australia, South Korea and Singapore in the Far East.

The 1990 Gulf crisis has resulted in the deployment of Patriot launchers to defend US forces in the region and the sale of two Fire Units (with ATBM capabilities) to Israel. A further contract for six Patriot Fire Units (36 launchers, 6 AN/MPQ-53 radars and 6 AN/MSQ-104 engagement control centres) with 384 missiles has also been agreed for Saudi Arabia. All the systems are being supplied as ex-US Army stock from 1993 onwards. A further sale of 14 Fire Units and 700 missiles was being notified to Congress in late 1991. The deal is worth an estimated \$3.3 billion. Total Saudi Arabian requirement is for 26 Fire Units.

#### Description

The MIM-104A Patriot missile is a certified round which is shipped, stored and fired from its Martin Marietta rectangular box-like container-launcher. Each canister-launcher box is 6.1 m long, 1.09 m wide and 0.99 m high. Weight empty is 794 kg and loaded 1696 kg. The missile requires no testing or maintenance in the field, periodic lot sampling of missiles on launchers, and in storage provides assurance of the weapon's capability. In configuration it is a single stage missile with four sections. At the front is the Raytheon guidance and radome compartment containing the autopilot controls, guidance electronics and the monopulse seeker unit with its steerable 30.5 cm diameter antenna. Next is the warhead section made by Picatinny Arsenal which contains four flush-mounted guidance antennas, inertial sensors and the E/F-band fuzing (M818E1), arming and blast fragmentation warhead devices. This is followed by the high strength steel propulsion section which contains a Thiokol 11.5 second burn 10 909 kg thrust TX-486 solid propellant rocket motor. At the tail is the Martin Marietta control section which supports the control actuation system, four



The four-round M901 Patriot launcher used by the German Air Force mounted on the rear of a MAN (8 × 8) truck for improved cross-country mobility. The vehicle is known by the designation Startstation LS

aerodynamic control surfaces and two further flush-mounted guidance antennas.

Velocity at motor burn out is 1700 m/s with the missile able to undertake 20 g continuous manoeuvres and 30 g short term manoeuvres. This allows it to cope with targets performing continuous 6g evasive manoeuvres.

Maximum flight time is 170 seconds and minimum flight time (that is, time required to arm) is 8.3 seconds.

In the field the Patriot battery consists of an AN/MPQ-53 phased-array radar mounted on a two-axle M860 semi-trailer with a 5 ton (6 × 6) M818 truck as the tractor, a 6 × 6 truck-mounted AN/MSQ-104 Engagement Control Station (ECS), an AN/MSQ-24 6 × 6 power plant truck with two 150 kW diesel powered gas turbine AC generator units, two firing platoons each with four four-tube M901 launching stations on M860 trailers with their own individual 15 kW generators and secure VHF data links to the ECS and M818 tractors. There is also support equipment in the form of missile reload trailer transporters and their tractors, a maintenance centre truck and trailer, a battery replaceable unit small truck transporter, and a large battery replaceable unit semi-trailer transporter with a maintenance vehicle tractor. There can also be a 6 × 6 truck with a GTE/Sylvania extendable AMG for communications with battalion HQ, other units and higher echelons.

Communications within the battalion is via voice and digital data. Six operational nets, two data and four voice, are used with at least 50 km between the Battalion's Command and Co-ordination ICC and up to six ECSs, 40 km between each ECS and at least 1 km between the ECS and M901s in a typical deployment pattern.

#### AN/MSQ-104 Engagement Control Station (ECS)

This is the only manned station in the Patriot battery and requires three operators. Inside are two operator console positions, one communications station, the digital weapons control computer, the VHF data link terminal, three radio relay terminals and the battery status panel with a hard copy unit beneath. In operation it sequences the battery through all tactical engagement procedures, monitors the operational status of the various systems, conducts automatic fault finding and location as required, and provides the human control part of the man-machine interface for the battery.

A typical engagement involves the radar being assigned its search sector then automatically adapting itself via the ECS's No 2 operating station with its environmental control panel to both the natural and hostile electronic environments it finds. It then modifies its operational functions as required. The radar search is carried out by the surveillance and detection beam with the radar informing the ECS when a detection occurs. The ECS then verifies the track by looking at several returns and at the appropriate time initiates IFF interrogation using the target track and illumination beam. The ECS then orders all tracks, establishes their engagement priorities and schedules the engagement. When an engagement decision is made, either in the manual, semi-automatic or fully automatic mode, the ECS selects the launcher to be used and sends any pre-launch data to the chosen missile through the VHF data link. It also notifies the radar at the time of launch as to where to look for the missile. The initial course turn executed by the weapon is either commanded by the simple, self-contained guidance system aboard or by the preset launch instructions from the ECS. Once in the air

the missile is acquired by the radar and this initiates a missile track and command uplink beam to monitor its flight and command it to follow, using instructions from the ECS computer, an efficient energy saving trajectory to the vicinity of the designated target. At this point the TVM terminal homing technique, described below, using the missile's onboard TVM track and downlink systems is initiated by the ECS. Just before the missile's closest approach to the target, the warhead is detonated, to produce a fragmentation pattern of 1.94 g splinters, by the E/F-band proximity fuzing device.

The Patriot ECS can also display the air picture from an E-3 Sentry AWACS aircraft via an automatic data link through the appropriate NATO/USAF sector operations centre and command, control and communications centre. The Tactical Control Officer can then pass any relevant track information to other air defence assets such as Chaparral or Stinger units/teams by FM radio.

### AN/MPQ-53 Multi-function Phased-Array Radar

The AN/MPQ-53 G-band frequency-agile phased-array radar is automatically controlled from the ECS by the digital weapons control computer. Mounted on a trailer it has a 5161 element array for the search and detection, target track and illumination and missile command and uplink beams. At any one time the system can handle between 90-125 target tracks and be able to support up to nine missiles in their final moments of engagement using TVM terminal homing. This technique involves the missile's passive monopulse seeker array being directed by the ECS to look in the direction of the target. This then begins to intercept increasingly precise returns from the reflected electromagnetic energy signals. This in turn triggers the G/H-band onboard downward data link which is offset in frequency from the target track and illumination beam and which transmits target data from the missile guidance package to the ECS computer via the circular 251-element TVM receive-only array at the lower right of the antenna group. The ECS uses this information to calculate guidance instructions which are passed to the missile by the radar's G/H-band command and uplink beam. The phase-coded information is received on the missile by the two sets of guidance antennas which transmit it to the guidance electronics which in turn use it to move the control surfaces. This procedure is repeated until the point of closest approach when the warhead is detonated. At no time throughout the engagement is any data actually processed on the missile itself.

Radar interrogation of a target is carried out by an AN/TPX-46(V)7 IFF system using a linear antenna array set below the main array position. There are also five diamond-shaped 51-element arrays: two individual ones above the IFF array set at the bottom corners of the main array and a set of three centred below the level of the TVM receiver array near the lower edge of the front face of the planar radar housing. These are sidelobe cancellers used to reduce the effects of enemy jamming. In a jamming environment the TVM technique is still usable because the system can measure range difference and as it already has the angular measurement of the target it can determine the difference in path length without loss of range resolution. It has the same range resolution as a non-jamming target engagement.

The 3 to 170 km range radar performs its surveillance, tracking, guidance and ECCM functions in a time-shared manner by using the weapon's computer to generate 'action-cycles' that last in milliseconds. Up to 32 different radar configurations can be called up with the beams tailored for long-range, short-range, horizon and clutter, guidance and ECCM functions in terms of their power, waveform and physical dimensions. The data rate for each function can also be independently selected to give 54 different operational modes so that, for example, a long-range search can be conducted over a longer time period than a horizon search for low altitude

pop-up targets. None of the functions requires any given time interval which therefore allows a random sequence of radar actions at any one time considerably adding to an attacker's ECM problem. The search sector is 90° and the track capability 120°.

When emplaced the radar is connected to both the ECS and generator vehicles by cabling.

### AN/MSQ-24 Electrical Power Plant

This comprises two turbine-driven Deko Products 150 kW AC generator units with power cable reels, control panel and fuel tank transported on the rear of a standard US Army 5 ton 6 x 6 truck. Either generator can supply the required power for both the ECS and radar.

### M901 Launcher Station

This is a remotely operated traversable four-round launcher station mounted on the rear of an M860 two-axle semi-trailer with its own 15 kW generator, data link terminal and electronics pack.

Time required to reload the full basic 20 missile complement of a five launcher battery is 60 minutes.

### Variants

#### Patriot Development Programme

The Patriot Development Programme is the subject of a US/German component demonstration project to provide a low risk but much improved tactical air defence against SRBMs, low observable cruise missiles and aircraft and stand-off jammers (SOJs). The current Patriot work is using funds from the original US/German Roland-Patriot agreement and involves Raytheon, AEG, Martin Marietta, MBB and Siemens.

The US DoD and German MoD Memorandum of Agreement is defining Phase 2 Patriot. This will result in prototype flights tests in 1991. A full-scale development effort with actual production of the weapon will follow.

The main changes involved are improvements to the radar by introducing both a dual travelling-wave-tube transmitter and hardware design changes to reduce the system's internal noise and modifying the missile.

The radar changes are to enhance the effective radiated power level and reduce the signal-to-noise ratio components of the radar range equation in order to offset the reduction in the anticipated target's radar cross-section component.

The seeker programme was the subject of a 1989 NATO award for a two year Research and Development contract to complete the integration of the unit.

The modified Patriot missile has a 0.76 m long rocket motor extension and a Ka-band active radar seeker in addition to the normal TVM guidance system. Under certain circumstances the motor extension is expected to double the range of the weapon so it can engage AWACS aircraft flying over territory deep in the rear of an Army's sphere of operations. In the ATM role the motor will also allow the weapon to increase its engagement altitude so as to provide more time in engaging a multiple incoming SRBM raid.

The combination of the improvements will also give Patriot fire units the capability of driving SOJ aircraft such as the Antonov An-12 'Cub'-C, Mil Mi-8 'Hip-J' and Mil Mi-8 'Hip-K' over the horizon thus improving all the divisional and Corps level communications assets and the effective range of all radar-based systems within its vicinity which the jammers would otherwise have seriously degraded had they remained in line-of-sight to them.

The seeker itself uses a 0.406 m aperture and is designed to give considerable improvements in the missile's engagement envelope against



The German Air Force AN/MPQ-53 radar set for Patriot is mounted on the rear of a MAN (8x8) truck and is shown here in the operating configuration. The vehicle is known by the designation Radargerät RS



Patriot ECS installed on the rear of a MAN (6x6) truck and is used by the German Air Force. This is called the Feuerleitanlage ECS





Communications vehicle of the German Air Force Patriot system uses a MAN (4 x 4) truck and is called the Richfunklage

observable targets and allow the system to engage Soviet 'stealth' type cruise missiles. It will also permit the weapon to attack low altitude threats even if they remask themselves behind terrain features in trying to escape a missile.

One other area of improvement includes incorporating on the launchers of a fire unit the ability to allow them to be placed under the control of a neighbouring ECS whilst their own ECS and radar are being moved to another location.

### Patriot-HAWK Phase III Interoperability

With the introduction of the HAWK Phase III it will become possible for the Patriot ICC to supply target data to HAWK Assault Fire Units. This allows the HAWK to engage targets more quickly without the need for them to search for them in elevation and to share the more sophisticated IFF of the Patriot to clarify their identities.

They can also be used together in the ATM role with an April 1988 demonstration programme test using a Patriot radar to cue the High Powered Illuminator (HPI) radar of a HAWK III system onto a Patriot missile simulating a SRBM target. The HAWK then successfully destroyed it at 8000 m altitude and 8000 m downrange.

In November 1990 the US Army validated the HAWK anti-ballistic missile software with a live fire test, and in June 1991 tactical ballistic missile targeting data was passed from a Patriot air defence system via a secure digital communications link to a HAWK unit. This then successfully fired two missiles at the target using both HAWK and Patriot system software to control the interception. One HAWK achieved a direct hit and the other provided a warhead kill.

The HAWK/Patriot interoperability is already part of US Army air defence doctrine, entering service in 1988. The new capability was provided by the Patriot software change known as Post Deployment Build II (PDBII). The first operational test was by the 69th ADA Brigade using three batteries of the 8-43rd ADA (Patriot) Battalion and two AFP of B/3-60th ADA (I-HAWK) Battalion during Reforger 88. This was followed by the October 1988 Exercise Hammer when a composite I-HAWK/Patriot defence using the PDBII successfully engaged a mass raid of approximately 100 aircraft.

The Block 1 enhancement (with the Patriot PDB II changes) allows the integration of I-HAWK fire units into a Patriot battalion with automatic target identification and a complete air picture compilation (of all I-HAWK and Patriot tracks) as Battalion Track Data Records being made in the Patriot ICC. Automatic engagement recommendations are then made with target allocation to the appropriate Patriot/I-HAWK fire unit. In the latter case the allocation has to be made by manual means.

The complete data compilation record can also be provided directly by the ICC to an adjacent battalion's AN/TQA-73 missile minder via the Army Tactical Data Link 1 network if that unit has lost its own link to the parent ADA Brigade HQ. However, it will not pass remote tracks received from a higher echelon nor will it process adjacent I-HAWK battalion tracks that do not correlate with its own air picture.

The follow-on Block 2 enhancement (with the Patriot PDB III changes) brings the Brigade Operations Centre ICC concept into the picture as one of the Patriot Battalion ICCs will assume the role of a centralised battle management Brigade/Master Battalion ICC to combine information and then distribute engagement assignments to other subordinate battalions can either be grouped in an ADA brigade or cluster of several SAM battalions.

This will allow up to 12 I-HAWK fire units, six Patriot fire units or a mixed battalion force of up to a total of 10 fire units (in a ratio of two I-HAWK to one Patriot fire unit) to be integrated into a single command and control structure



German Air Force Patriot missile resupply vehicle which carries four missiles and tows a trailer carrying a further four missiles

using appropriate Army Tactical Data Link 1 and Patriot Digital Information Link networks.

The Master ICC will be able to control both AN/TSQ-38 and AN/TSQ-73 systems as well as another ICC. It will also be able to implement remote track reception from higher echelons and process adjacent I-HAWK battalion tracks to correlate with its own air picture.

Additionally it provides a full track management facility and is able to perform automatic threat ordering, identification processing of I-HAWK Phase II/Phase III and Patriot fire unit data and target allocation tasking to all its subordinate Patriot and/or I-HAWK battalions but not to individual fire units themselves.

When the recipient battalion assigns the target to one of its fire units for engagement the other fire units in the battalion are notified by messages appropriate to their systems.

The programme to provide these capabilities is being pursued jointly by the USA, the Netherlands and Germany.

### SPECIFICATIONS (missile)

TYPE	single stage, low to high altitude
LENGTH	5.18 m
DIAMETER	0.41 m
WING SPAN	0.92 m
LAUNCH WEIGHT	about 700 kg
PROPULSION	single stage solid propellant rocket motor
GUIDANCE	command with TVM semi-active homing
WARHEAD	91 kg HE-blast fragmentation with proximity fuzing
MAX SPEED	Mach 3.7
MIN RANGE	3000 m
MAX RANGE	160 000 m
MAX ALTITUDE	24 240 m
MIN ALTITUDE	60 m
LAUNCHER	mobile trainable four-round semi-trailer

**Status:** In production - PAC-2 missile variant only (entered production 1989). By 1993 over 740 launchers and 5000 plus missiles will have been assembled by US manufacturers. In service with or on order for the following countries:

Country	No of launchers needed	Service
Germany	320	Air Force (40 squadrons)
Israel	16	Air Force (2 batteries) *
Italy	100	Air Force (20 batteries)
Japan	130	Air Force (26 batteries)
Netherlands	64	Air Force (8 squadrons) **
Saudi Arabia	36	Air Force (6 batteries) *
USA	480	Army (60 batteries)

**Notes:** \* additional batteries being procured following Gulf War.

\*\* Late in 1991 it was announced that the Royal Netherlands Air Force plans to relocate its eight German-based SAM squadrons to De Peel Air Base in the Netherlands. At the same time the Dutch Patriot and Improved HAWK units are to be merged into four composite squadrons.

The four Patriot and four Improved HAWK squadrons now form part the 3rd and 5th Netherlands Missile Groups headquartered at Blomberg and Stolzenau as part of the NATO SAM belt in Germany, and will move to the Netherlands in 1994-96.

The two groups will be merged into one 900' strong group at De Peel comprised of four TRIAD (Triple Air Defence) squadrons. TRIAD integrates Patriot and I-HAWK radar and fire control assets to form a squadron with one Patriot and two Improved HAWK fire platoons and one information co-ordination centre.

**Manufacturers:** Prime system contractor: Raytheon Company, Missile Systems Division, Bedford, Massachusetts 01730, USA.  
Telephone: (617) 274 2222.

Principle subcontractor: Martin Marietta Aerospace, Orlando, Florida, USA.  
Principle German Patriot contractor: Siemens AG, Postfach 70074, D-8000 Munich, Federal Republic of Germany.  
Principle Japanese Patriot contractor (licence builder): Mitsubishi Heavy Industries, 5-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo, Japan.  
ARM-D System: Brunswick Corporation, Brunswick Defense Division, Skokie, Illinois 60077, USA.  
Telephone: (312) 470 4797.

## Nike-Hercules (MIM-14B) Surface-to-air Missile System

### Development

Development of the Nike-Hercules SAM system commenced in 1954 with prime contractor being Western Electric Company of Burlington, North Carolina.

The Nike-Hercules was developed as the replacement for the older Nike-Ajax (MIM-3) which was range limited and only had an HE warhead. A total of 15 000 Nike-Ajax missiles were produced but none remain in service. The Nike-Ajax was also supplied to Belgium, Denmark, France, Germany, Greece, Italy, Japan, the Netherlands, Norway, Taiwan and Turkey.

Delivery of production Nike-Hercules systems to the US Army commenced in January 1958 and was completed in March 1964, although production for export continued after this date. Three different models of the Nike-Hercules were produced: the MIM-14A, MIM-14B and MIM-14C, the MIM-14B being the most common. Total production amounted to over 25 500 missiles of which 2650 were exported under the Foreign Military Sales programme and 1764 under the Military Aid Program (MAP). Production of the missile was undertaken at the US Army Ordnance Missile Plant at Charlotte, North Carolina, run by the then Douglas Aircraft company.

The Nike-Hercules was deployed by the US Army in the static role in the United States (including Alaska) as well as in Germany and South Korea.

In the Continental United States (CONUS) static versions were employed to provide defence of critical installations and urban population centres while semi-mobile units were deployed to protect field armies and theatres of operation.

In the US Army each air defence battalion consisted of a headquarters battery and four firing batteries. Each battery can operate as part of an air defence network or as an autonomous unit and is capable of multiple launches during a single engagement.

It was designed to engage aircraft flying at altitudes up to about 45 000 m and at ranges of up to 145 km and during trials successfully intercepted short-range ballistic missiles such as Corporal and other Nike-Hercules missiles. The missile can also be used in the ground-to-ground role with a contact fuzed nuclear warhead.

It has been supplied to a number of NATO countries and a non-nuclear version was produced under licence for the Japanese Air Force by Mitsubishi Heavy Industries. This version is known as the Nike-Hercules-J.

Deployment of the Nike-Hercules in the US Army reached its peak in 1963 when no fewer than 134 batteries were operational in the CONUS as well as Alaska, Okinawa, Taiwan and Germany. By 1974 they had all been disbanded in the CONUS apart from those retained for training. The successor to Nike-Hercules is the much more capable Patriot system.

### Description

The actual Nike-Hercules missile is two-stage consisting of a solid-propellant,



*Nike-Hercules on its launcher, ready for launch (US Army)*

computer-controlled missile body and a cluster of four solid propellant booster rockets. The missile airframe, wings and booster clustering hardware are made of aluminium and the booster cases are steel.

The missile body is sharply tapered at the nose and is faired back to a maximum diameter of 800 mm and the rear end of the body is faired back to a maximum diameter of 538 mm. The missile has four delta-shaped wings, with elevons to control roll and steering. Four small linearisation fins are attached forward of the wings.

The booster cluster is composed of four individual booster rockets and has a cross-sectional width of 877 mm with the four trapezoidal fins attached to the aft end of the cluster.

The Nike-Hercules is launched by remote-control, normally at an angle of about 85° and when the booster is jettisoned the guidance system is activated, programming the missile to roll toward the target and dive into the intercept plane. Steering orders direct the missile to the optimum burst point. The warhead is either the high explosive or nuclear type. The latter is designated W31 with some 2550 being produced.

Two separate time-fuzed tritium boosted or alloy W-31 Mod 2 nuclear warhead sections were deployed, the 510.5 kg M22 and M97, which are interchangeable. Nike-Hercules has an electronic countermeasures capability.

In addition to the missile itself, key components of Nike-Hercules are a low power acquisition radar, high power acquisition radar, target tracking radar, missile tracking radar, electronic data processing equipment and remote-controlled launchers.

After the system was in service for some years a later development, the high power acquisition radar (HIPAR), enabled mobile versions of the Nike-Hercules to get the same full target detection capability as the batteries at fixed sites.



*Nike-Hercules-J of the Japanese Air Self-Defence Force on its two-axle M529 transport-trailer being towed by a Type 73 (6 x 6) 3500 kg truck (Kensuke Ebata)*





Nike-Hercules missile showing four boosters at rear (US Army)

The HIPAR has three vans housing radar transmitter, receiver and control equipment and one of the two semi-trailers hauls the 13.1 m wide fan-shaped antenna while the other carries the generators. Before the introduction of HIPAR some 20 vehicles were required to move the radar system.

In operation the target is first detected by the acquisition radar and is then interrogated by the associated AN/TPX-46 IFF Mk XII interrogator, and if confirmed as hostile its location is transferred to the target tracking radar which pin-points it for intercept purposes.

When the target is within range a missile is launched and the missile tracking radar issues guidance and orders to the missile until it reaches the target.

The system operators are located in a battery control trailer, a tracking control trailer and a launcher control trailer.

In 1981 contracts were placed for a number of improvements to the system with McDonnell Douglas refurbishing and modifying NATO Nike-Hercules missiles.

Norden Systems has provided the Digital Computer System which is based on the PDP-11/34M mini-computer. This receives missile and target position inputs from tracking radars, solves the intercept problem and issues guidance commands to the missile. In addition it performs various routines such as fault diagnosis.

#### Variants

South Korea is known to have produced a version of the Nike-Hercules optimised for the ground-to-ground role. At least two batteries are believed to have been converted to this configuration.

#### SPECIFICATIONS (missile)

TYPE	two-stage, medium to high altitude
SHAPE	symmetrical cruciform
GROSS WEIGHT	4858 kg
first stage	2350 kg
second stage	2509 kg
LENGTH	12.141 m
first stage	4.34 m
second stage	8.19 m
DIAMETER	
min	538 mm
max	800 mm
SPAN	
first stage	8.191 m
second stage	2.286 m
GUIDANCE	command



Nike-Hercules surface-to-air missile being launched

#### STEERING

hydraulically actuated control surfaces  
solid

#### PROPELLANT TYPE

#### PROPELLANT CONFIGURATION

first stage rod and tube charge  
second stage internal burning star

#### MAX SPEED

MIM-14A

Mach 3.35

MIM-14B/C

Mach 3.65

#### MAX ALTITUDE

45 720 m (approx)

#### MIN ALTITUDE

1000 m (approx)

#### MAX RANGE

145 km (approx)

#### IN-FLIGHT POWER SOURCE

battery

#### LAUNCHER TYPE

monorail

#### WARHEAD

nuclear or HE

#### LAUNCH CREW

45 men

**Status:** Production complete. In service with:

Country	No of launchers	Operator
Greece	36	Air Force, 1 group
Italy	96	Air Force, 8 groups, to be replaced by Patriot
Japan	180	Air Force, 6 groups of 18 squadrons now being replaced by Patriot
Korea, South	90	Army, 2 battalions, with 10 batteries (also used in surface-to-surface role)
Norway	12	Air Force, 1 battalion with 2 batteries, to be replaced by NASAMS
Spain	9	Army, 1 battery
Taiwan	36	Army, 2 battalions
Turkey	72	Air Force, 8 squadrons each with 9 launchers

**Manufacturer (prime):** Western Electric Company (now AT & T Technologies), Burlington, North Carolina.  
Major subcontractors: AAI Incorporated, Bell Telephone Laboratories, General Electric Company, McDonnell Douglas Astronautics, Raytheon Company.

## Theatre High Altitude Area Defense Missile (THAAD)

### Development/Description

The US Army's Strategic Defense Command (SDC) is preparing to issue a Request For Proposals (RFP) to Industry for the THAAD system. This is envisaged as an easily transportable battery of weapons capable of hit-to-kill collisions with incoming tactical and theatre ballistic missiles at heights as much as 20 to 150 times greater than those defended by Patriot. This would then allow the current air defence system to preserve their primary mission of anti-aircraft defence.

The THAAD system, including launchers and fire control elements is conceived of as being based on air transportable trucks. It would be cued either by space-based sensor satellites such as Brilliant Eyes or an I/J-band Ground-Based Radar (GBR). The latter is to be the subject of a separate development programme calling for two radars to be delivered. The design can feature either travelling wave tube or solid-state technology as long as the performance requirements are met. However, for the eventual production system the latter is expected. The three companies seeking the contract are Raytheon Corporation, Westinghouse Electric Corporation and General Electric.

The potential contractors for the THAAD programme are three teams:

- (a) team leader Hughes Aircraft Company, with LTV Corporation, General Electric, Sparta Corporation, Thomson-CSF Incorporated and TRW Incorporated
- (b) team leader Lockheed Missiles & Space Company, with Dornier GmbH, Honeywell Incorporated, Israel Aircraft Industries Limited, Litton Corporation, Loral Corporation, Rockwell International Corporation, United Technologies Corporation and Westinghouse Electric Corporation
- (c) team leader McDonnell Douglas Space Systems Corporation, with

Aerojet-General, Harris Corporation, Martin Marietta Corporation, Raytheon Corporation, Rockwell International Corporation and BGT (of Germany).

One team will be selected for the 57 month company demonstration and validation phase, with 10 test flights to be conducted in 1994. It is intended that a deployable demonstration model system will be delivered whilst these firings are under way. An additional 10 flights will be performed by operational personnel and up to 60 missiles would be procured as an interim for the 'national emergency' stockpile and combat use. The demonstration/validation unit must be capable of actually deploying to a crisis zone by 1996.

The full-scale development contract could be awarded as early as FY94. Funding has been requested for in the FY92 budget with more planned in FY93. Actual production units will follow at a later date from 1996.

The extremely fast THAAD missiles are expected to engage targets out to 200 km plus and intercept missiles as high as 150 000 m in altitude. The latter is especially needed in order to safely engage weapons with nuclear, biological or chemical warheads.

In a scenario known as 'shoot-look-shoot' THAAD weapons engaging two possible targets should have a Single Shot Kill Probability of 0.9. The terminal phase of the attack employing onboard infra-red sensors to close in on the target missile.

The THAAD system must also be able to cue other weapon systems and interface with other air defence data information networks to allow battle management and command, control and communications tasking of highly complicated attack scenarios in a distributed manner.

The THAAD system could thus form a layered defence of high value targets such as airfields with complementary weapon systems such as the Raytheon Patriot or LTV Extended Range Interceptor (ERINT).

**Status:** Entering RFP phase to a formal operational requirement.

## LTV Extended Range Interceptor (ERINT) Programme

### Development

The ERINT design programme started in 1983 but flight testing was not funded until 1987 when the prime contractor, LTV Missiles Division, was awarded a three year development contract worth \$80 million. Originally conceived as a follow-on from the earlier Flexible Lightweight Agile Guided experiment (FLAGE) for intercepting tactical ballistic missiles (TBMs) at altitudes in excess of 15 000 m the programme has now been extended to provide an intercept capability against both short-range TBMs and air-breathing missiles. The revised programme is now known as ERINT-1.

The trials programme consists of two aerodynamic, four guided (against simulated TBM targets) and two guided (against simulated air-breathing missile targets) flight tests at the White Sands Missile Range during 1992-93.

It is possible that the ERINT system may form part of an overall layered theatre air defence network which will also include the Patriot and THAAD systems.

### Description

The ERINT-1 is designed to utilise the Patriot launcher unit. It is 4.62 m long, has a maximum body diameter of 0.25 m and weighs 300 kg at launch. The final full-scale development configuration is expected to be at least 50 per cent lighter.

The weapon has four clipped-tail delta wings just aft of its centre and some 240 mini-solid propellant altitude control thruster motors mounted in a special attitude control section located in its forebody section to effect flight control manoeuvres. A high performance solid propellant rocket motor is used as the propulsion system.

It uses an inertial guidance package for the mid-course guidance phase, to fly to the predicted intercept point. Initial target data is acquired by the

system's fire control radar which pre-programmes the onboard guidance package before the launch.

If required the weapon's trajectory can be updated during the flight using the fire control radar system. In the last two seconds of the flight a radome covered nose-mounted gimballed K-band radar seeker antenna assembly is activated to terminally guide the missile to the target. The radar also doubles as the proximity fuzing system to detonate the HE-fragmentation warhead. This uses high density tungsten pellets to enhance its effectiveness. Weapon range is quoted as 15 000 m with the ERINT designed to intercept short-range TBMs at a closing velocity of 3500 m/s.

### SPECIFICATIONS (provisional)

TYPE	short-range, high performance, single stage theatre defence
LENGTH	4.62 m
DIAMETER	0.25 m
WEIGHT	300 kg
WARHEAD	HE-fragmentation
GUIDANCE	inertial with command update capability and K-band active radar terminal homing
	solid propellant rocket motor with special attitude control section for in-flight control manoeuvring
MAX ALTITUDE	15 000 m plus
MAX RANGE	15 000 m

**Status:** Development.

**Manufacturer:** LTV, Missiles and Electronics Group, Missiles Division, PO Box 650003, Dallas, Texas 75265-0003, USA.  
Telephone: (214) 266 1824

## US Army Corps Surface-to-air Missile System (CORPS SAM)

### Development/Description

The CORPS SAM mission is defined as providing an effective air defence capability against air-breathing and tactical missile threats in support of contingency and mature theatre operations. The threats include TBMs and low to medium altitude aircraft, helicopters, drones, UAVs, RPVs, tactical ASMs and cruise missiles.

The CORPS SAM will effectively replace the Improved HAWK system from around the year 2000 and must be able to interface with other theatre and battlefield defence systems in order to provide a layered air defence network designed to counter all enemy airborne threats. Its primary role will be the protection of critical Corps assets and will have an enhanced ability

to reinforce Divisional air defences. Its designed flexibility will also allow it to contribute to the theatre level air defence. It must also be able to be rapidly configured for movement and be deployable by land, sea or air assets. The latter including the Lockheed C-130 Hercules transport.

The systems operational description was presented to Industry in August 1991 and this will be followed by concept definition proposals from Industry. The contract should follow in 1992 with the demonstration and validation phase thereafter.

Companies known to be interested in the programme include General Electric, Hughes Aircraft, LTV, Martin Marietta and Raytheon. International co-operation is also possible with NATO partners, Israel and Japan to facilitate cost sharing.

**Status:** Concept definition phase.



# Inventory

This excludes weapons operated by local resistance and guerrilla units and in some cases updates that in the main text.

## AFGHANISTAN

### Air Force

3 battalions SA-2 'Guideline' SAM (18 launchers)  
3 battalions SA-3 'Goa' SAM (12 × 4-round launchers)  
37 mm M1939 AAG  
57 mm S-60 AAG  
85 mm KS-12 AAG, with Fire Can radar

### Army

SA-7 'Grail' manportable SAM  
SA-13 'Gopher' SAM (16+)  
12.7 mm LAAG including M53 (4 × 12.7 mm in rear of BTR-152 APC), also used by militias and Ministry of Interior Armed Forces  
14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG, also used by militias and Ministry of Interior Armed Forces  
23 mm ZSU-23-4 SPAAG (20)  
23 mm (twin) ZU-23 LAAG, also truck-mounted for convoy escort  
57 mm S-60 AAG  
85 mm KS-12 AAG, with Fire Can radar  
100 mm KS-19 AAG



*Captured Afghan SA-2 'Guideline' SAM on its resupply trailer*



*ZSU-23-4 self-propelled anti-aircraft guns of the Afghan Army on parade*

## ALBANIA

### Air Force

4 battalions (SA-2 or HQ-2) SAM (24 launchers)

### Army

23 mm (twin) ZU-23 LAAG, from China  
37 mm M1939 AAG (50)  
57 mm S-60 AAG  
85 mm KS-12 AAG

## ALGERIA

### Air Force

7 battalions SA-2 'Guideline' SAM (42 launchers)  
1 battalion SA-3 'Goa' SAM (14 launchers)  
85 mm KS-12 AAG (30+), with Fire Can radar  
100 mm KS-19 AAG (150)

### Army

SA-7 'Grail' manportable SAM  
5 battalions SA-3 'Goa' SAM (30 launchers)  
40 SA-6 'Gainful' SAM  
20 SA-8 'Gecko' SAM  
40+ SA-9 'Gaskin' SAM  
32 SA-13 'Gopher' SAM  
14.5 mm ZPU-2 and ZPU-4 LAAG (50)  
23 mm (twin) ZU-23 LAAG (65)  
23 mm ZSU-23-4 SPAAG (210)  
37 mm M1939 AAG (150)  
57 mm S-60 AAG (75)  
85 mm KS-12 AAG (20+), with Fire Can radar  
130 mm KS-30 AAG (20) (unconfirmed)

## ANGOLA

### Air Defence Force

3 battalions SA-2 'Guideline' SAM (18 launchers)  
12 battalions SA-3 'Goa' SAM (48 launchers)  
72 SA-6 'Gainful' SAM  
72 SA-8 'Gecko' SAM  
30 SA-9 'Gaskin' SAM  
30+ SA-13 'Gopher' SAM  
23 mm (twin) ZU-23 LAAG  
57 mm ZSU-57-2 SPAAG (40)

### Army

SA-7 'Grail' manportable SAM  
SA-14 'Gremlin' manportable SAM  
SA-16 'Gimlet' manportable SAM  
14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
23 mm (twin) ZU-23 LAAG  
23 mm ZSU-23-4 SPAAG (20+)  
37 mm M1939 AAG  
57 mm S-60 AAG (70)

## ARGENTINA

### Air Force

20 mm (twin) TCM-20 LAAG, (24+), used with Elta EL/M 2106 point defence alert radar

### Army

Blowpipe manportable SAM (also Special Forces)  
SA-7 'Grail' manportable SAM system (and Air Force)  
10 Short Tigercat SAM  
4 shelter-mounted Roland 2 SAM systems  
35 mm (twin) Oerlikon-Contraves AAG, 100 system total for use by Army (Skyguard FCS), Air Force (Super Fledermaus FCS) and Marines  
40 mm M1 AAG  
40 mm Bofors L/60 AAG (may have been replaced by Bofors L/70)  
40 mm Bofors L/70 AAG (built under licence) and used with fire control system  
90 mm M117 AAG (12 held in reserve)

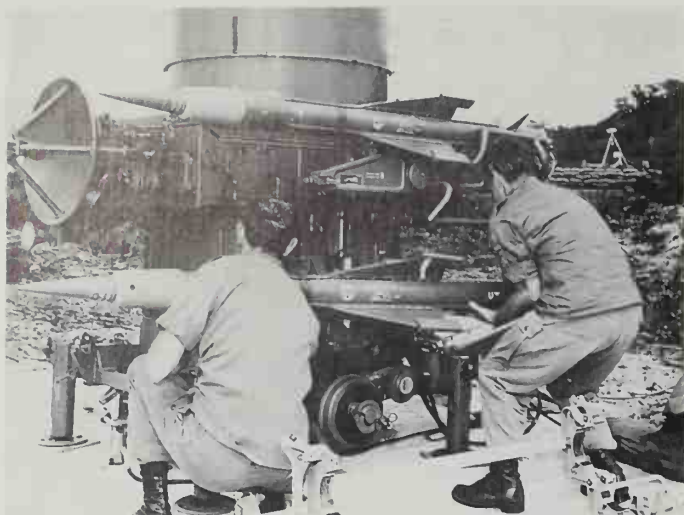
### Marines

Blowpipe manportable SAM system  
RBS 70 SAM  
Short Tigercat SAM  
30 mm Hispano-Suiza AAG  
35 mm (twin) Oerlikon-Contraves AAG

## AUSTRALIA

### Army

RBS 70 short-range SAM system selected after competition in 1985, 60 launchers plus missiles ordered to replace Redeye FIM-43 manportable SAM



*Australian Army crew reloading their Rapier SAM launcher during trials*

#### **Army (continued)**

Rapier SAM, 20 optical systems ordered in 1975, first deliveries 1978, Blindfire radars ordered 1978

#### **AUSTRIA**

##### **Air Force**

35 mm (twin) Oerlikon-Contraves GDF-002 AAG (18) (with Super Fledermaus FCS)

##### **Army**

20 mm (single) Oerlikon-Contraves GAI-B01 LAAG (552), including some mounted on rear of Pinzgauer (6 × 6) truck

35 mm (twin) Oerlikon-Contraves GDF-002 AAG (74) (with Super Fledermaus FCS)

40 mm (twin) M42 SPAAG (38)

40 mm Bofors L/70 AAG (60) with Skyguard and Super Fledermaus FCS

**Note:** (1) GDF-002 have been upgraded to GDF-005 standard; weapons are called the 3.5 cm Zwillings FIAMK 75 bzw 79 while Skyguard is known as the Feuerleitgerät 75 bzw. 79

(2) Austrian Army has a requirement for a manportable SAM



*M42 twin 40 mm SPAAG of the Austrian Army (Austrian Army)*

#### **BAHRAIN**

##### **Army**

60 RBS 70 SAMs in service since 1980

Stinger FIM-92A manportable SAM

#### **BELGIUM**

##### **Air Force**

2 battalions of HAWK SAM (36 launchers) (plus 3 in reserve)

**Note:** Nike Hercules SAMs have been phased out of service without replacement

##### **Army**

Late in 1988 Belgium placed an order for 714 Mistral SAMs worth an estimated \$93 million with deliveries to take place from 1992. The Belgian Air Force may order 300 Mistral systems for air base protection

20 mm M167 VADS (towed) (36)

35 mm Gepard SPAAG (55)

#### **BENIN**

##### **Army**

SA-7 'Grail' manportable SAM system

4 SA-9 'Gaskin' SAM

14.5 mm ZPU-4 LAAG

#### **BOTSWANA**

##### **Army**

SA-7 'Grail' manportable SAM

Javelin manportable SAM

20 mm M167 AAG (delivered 1989)

#### **BRAZIL**

##### **Army**

A competition for manportable SAM system is underway while AVIBRAS is designing the Solar air defence missile system to meet requirements of Brazilian Army, Orbita is proposing a system using technology from the BAe Thunderbolt SAM, but as of late 1991 no firm contracts had been placed

4 Roland 2 SAM on Marder chassis

12.7 mm M55 towed anti-aircraft gun system (including modernised)

35 mm (twin) Oerlikon-Contraves GDF-001 AAG (38) with Super Fledermaus FCS, AVIBRAS has developed FILA (Fighting Intruders at Low Altitude) FCS for use with Brazilian AAGs



*Brazilian AVIBRAS FILA fire control system*



*Brazilian Army locally built Bofors 40 mm L/70 anti-aircraft gun (Mario Roberto V Carneiro)*





*Roland 2 surface-to-air missile system on Marder chassis of the Brazilian Army (Mario Roberto V Carneiro)*

#### **Army (continued)**

40 mm M1 AAG (40)  
 40 mm Bofors L/60 AAG (may have been replaced by L/70)  
 40 mm Bofors L/70 AAG (36+), some with BOFI  
 90 mm M117 AAG (40 held in reserve)

#### **BRUNEI**

##### **Army**

Rapier SAM ordered in 1978, first deliveries 1983, believed 12 launchers plus 4 Blindfire radars in service

#### **BULGARIA**

##### **Air Force**

22 battalions SA-2 'Guideline' SAM (132 launchers)  
 34 battalions SA-3 'Goa' SAM (136 launchers)  
 SA-10b 'Grumble' SAM (2 battalions)  
 SA-5 'Gammon' SAM

##### **Army**

SA-7 'Grail' manportable SAM  
 27 SA-4 'Ganef' SAM  
 40 SA-6 'Gainful' SAM  
 50+ SA-9 'Gaskin' SAM  
 20 SA-13 'Gopher' SAM  
 14.5 mm ZPU-2 and ZPU-4 LAAG (held in reserve)  
 23 mm (twin) ZU-23 LAAG (300)  
 23 mm ZSU-23-4 SPAAG (35)  
 37 mm M1939 AAG (reserve)  
 57 mm S-60 AAG  
 85 mm KS-12 AAG, with Fire Can radar

#### **BURKINA FASO**

##### **Army**

SA-7 'Grail' SAM  
 14.5 mm ZPU series LAAG (30)

#### **BURMA**

##### **Army**

40 mm M1 AAG (10)

#### **BURUNDI**

##### **Army**

14.5 mm ZPU-4 LAAG (15)

#### **CAMBODIA**

##### **Army**

37 mm M1939 AAG  
 57 mm S-60 AAG  
 SA-7 'Grail' manportable SAM

#### **CAMEROON**

##### **Army**

14.5 mm Type 58 LAAG (copy of Soviet ZPU-2) (18)  
 35 mm (twin) Oerlikon-Contraves AAG (6) with Super Fledermaus FCS  
 37 mm M1939 AAG (18) (from China)

#### **CANADA**

##### **Armed Forces**

Javelin manportable SAM  
 Blowpipe manportable SAM (first order placed in 1973)  
 36 Oerlikon-Contraves ADATS, 20 GDF-005 twin 35 mm towed anti-aircraft guns and 10 Skyguard fire control systems  
 Four GDF-005s are at the Low Level Air Defence School at Chatham, with eight each at Baden (128 Air Defence Battery) and Lahr (129 Air Defence Battery), Germany. Of the 30 ADATS systems, 24 will be deployed in Europe to provide mobile air defence to field units



*Canadian Armed Forces Skyguard FCS in action with outriggers deployed (Canadian Armed Forces)*

#### **CAPE VERDE ISLANDS**

##### **Army**

SA-7 'Grail' manportable SAM  
 14.5 mm ZPU-2 and ZPU-4 LAAG

##### **CHAD**

**Note:** French air defence systems deployed to Chad in the last few years include GIAT 20 mm anti-aircraft guns (both towed and ACMAT truck-mounted), Crotale SAMs and HAWK SAMs. The latter have protected the main air base at the Chad capital of N'Djamena, while the Crotale have also defended the airstrip at Abeche in the north-east of the country

##### **Army**

SA-7 'Grail' manportable SAM  
 FIM-92A Stinger manportable SAM  
 FIM-43 Redeye manportable SAM  
 14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
 23 mm (twin) ZU-23 LAAG

**Note:** Some LAAG have been mounted on rear of cross-country trucks for increased mobility

#### **CHILE**

##### **Air Force**

Blowpipe manportable SAM (also operated by Marines)  
 Javelin SAM underwent trials in early 1988  
 SATCP Mistral manportable SAM  
 2 Crotale acquisition and 4 Crotale SAM firing units  
 12.7 mm (twin) LAAG  
 12.7 mm (quad) M55 LAAG  
 20 mm FAM-2M twin 20 mm LAAG

##### **Army**

20 mm (single) Oerlikon-Contraves GAI-C04 LAAG  
 20 mm Rheinmetall (twin) LAAG  
 35 mm (twin) Oerlikon-Contraves AAG (24) operated by Army/Air Force  
 40 mm Bofors L/70 AAG (use unconfirmed)

## CHINA, PEOPLE'S REPUBLIC

## Air Defence Force

HQ-1 SAM (Soviet supplied SA-2)  
 HQ-2 SAM (improved version of Soviet SA-2 'Guideline')  
 23 mm (twin) LAAG (also Marines and militia)  
 57 mm S-60 (Type 59) AAG  
 85 mm Type 56 AAG  
 100 mm Type 59 AAG (copy of Soviet KS-19)

## Army

SA-7 'Grail' manportable SAM and Chinese HN-5/HN-5A versions, truck-mounted 4-round HN-5C under test  
 RF-61A SAM (twin launcher)  
 FM-80 SAM (quad launcher) under development  
 14.5 mm Type 56 LAAG (copy of Soviet ZPU-4)  
 14.5 mm Type 58 LAAG (copy of Soviet ZPU-2)  
 14.5 mm Type 75-1 LAAG (improved version of Soviet ZPU-1)  
 14.5 mm Type 75 LAAG (copy of Soviet ZPU-1)  
 14.5 mm Type 80 LAAG (improved version of Soviet ZPU-1)  
 23 mm (twin) (Type 80) LAAG (copy of Soviet ZU-23)  
 25 mm Type 85 LAAG (service use not confirmed)  
 37 mm (twin) Type 55 AAG (copy of Soviet M1939)  
 37 mm (twin) Type 65 AAG



Chinese Type 56 LAAG (left) and Type 55 LAAG (right)



Chinese JY-8 mobile tactical 3D radar system deployed (Eric Ditchfield)

## Army (continued)

37 mm (twin) Type 74 AAG  
 37 mm Type P793 AAG  
 All Chinese 37 mm AAGs can be used in conjunction with Type 311 series radar fire control system  
 57 mm Type 59 AAG (copy of Soviet S-60) used together with GW-03 fire control director  
 57 mm (twin) Type 80 SPAAG  
 57 mm ZSU-57-2 SPAAG  
 85 mm Type 56 AAG (copy of Soviet KS-12)  
 100 mm Type 59 AAG (copy of Soviet KS-19)

## COLOMBIA

## Army

40 mm M1 AAG (30)  
 40 mm Bofors L/70 (probably replaced 40 mm M1 AAG)

## CONGO

## Army

14.5 mm ZPU-4 LAAG  
 23 mm ZSU-23-4 SPAAG (8)  
 37 mm M1939 AAG (28)

## CUBA

## Army

SA-7 'Grail' manportable SAM  
 SA-14 'Gremlin' manportable SAM  
 12 SA-6 'Gainful' SAM  
 60 SA-9 'Gecko' SAM  
 40 SA-13 'Gopher' SAM  
 12.7 mm (quad) AA MG (believed to be in reserve)  
 14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
 23 mm (twin) ZU-23 LAAG (400)  
 23 mm ZSU-23-4 SPAAG (36)  
 30 mm (twin) M53 AAG, status uncertain (100)  
 30 mm SPAAG (local modification, BTR-60P (8 x 8) APC with twin Czech 30 mm automatic anti-aircraft gun system M53 installed  
 37 mm M1939 AAG (300)  
 57 mm S-60 AAG (200)  
 57 mm ZSU-57-2 SPAAG (25)  
 85 mm KS-12 AAG, and Fire Can radar (100)  
 100 mm KS-19 AAG (75)

## CYPRUS

SA-7 'Grail' manportable SAM  
 MATRA Mistral SAM systems delivered 1989 (manportable and Alamo versions)  
 20/3 mm M55 A2 LAAG  
 35 mm (twin) Oerlikon-Contraves GDF-005 AAG with Skyguard FCS  
 40 mm MK 1 AAG (20+)

## CZECHOSLOVAKIA

## Air Defence Command

30 mm (twin) M53 AAG (some of which are held in reserve)  
 20 battalions SA-2 'Guideline' SAM (120 launchers)



Czechoslovakian Army SA-8 'Gecko' SAM showing amphibious capabilities with surveillance radar stowed and turret traversed to the rear



**Air Defence Command (continued)**

30 battalions SA-3 'Goa' SAM (120 launchers)

Several battalions SA-5 'Gammon' SAM

Several battalions SA-10b 'Grumble' SAM

**Army**

SA-7 'Grail' manportable SAM (local production)

SA-14 'Gremlin' manportable SAM

120 SA-6 'Gainful' SAM

40 SA-8 'Gecko' SAM

80+ SA-9 'Gaskin' SAM

100+ SA-13 'Gopher' SAM

14.5 mm ZPU-4 LAAG, not in front line service, also used by militia

23 mm ZSU-23-4 SPAAG (100)

30 mm (twin) M53 AAG

30 mm (twin) M53/59 SPAAG

57 mm S-60 AAG (400)

**DENMARK****Air Force**

8 squadrons of HAWK SAM (48 launchers)

40 mm Bofors L/70 AAG (Super Fledermaus FCS by TERMA and SATT)

12.7 mm (quad) M55 LAAG

**Army**

FIM-92A Stinger manportable SAM

FIM-43 Redeye manportable SAM

12.7 mm (quad) M55 LAAG

40 mm Bofors L/60 (36), plus Super Fledermaus FCS

**DJIBOUTI****Army**

20 mm (twin) Tarasque 53T2 LAAG

23 mm (twin) ZU-23 LAAG

**DOMINICAN REPUBLIC****Army**

40 mm M1 AAG (20)

**ECUADOR****Air Force**

35 mm (twin) Oerlikon-Contraves GDF-003 AAG

**Army**

Blowpipe manportable SAM

20 mm Oerlikon-Contraves GAI-C01 LAAG

20 mm M167 VADS (towed) (28)

40 mm M1 AAG (30)

40 mm Bofors L/70 AAG (24)

**EGYPT****Air Defence Command**

60 SA-6 'Gainful' SAM system

13 batteries of HAWK SAM (total of 78 launchers)

60 SA-2 'Guideline' battalions (total 360 launchers)

55 SA-3 'Goa' battalions (total 220 launchers)

12 Crotale acquisition units and 24 Crotale firing units

18 Amoun batteries delivered 1984/1987 each with one Skyguard fire control system, two twin 35 mm Oerlikon-Contraves towed anti-aircraft guns and two four-round Sparrow SAM launchers

20 mm M53 LAAG

20 mm M57 LAAG

23 mm (twin) ZU-23 SPAAG (M113A2 chassis)

23 mm (twin) ZU-23 LAAG, and locally built version

37 mm M1939 AAG (400)

57 mm S-60 AAG (600)

85 mm KS-12 AAG, with Fire Can radars (400)

100 mm KS-19 AAG (300)

**Army**

SA-7 'Grail' manportable SAM system

20 SA-9 'Gaskin' SAM system

25 Chaparral SAM system (delivered 1988) (used in conjunction with seven M577A2 vehicles fitted with TRACKSTAR radar system)

Sakr Eye manportable SAM system

12.7 mm (quad) M53 AAG (reserve)

14.5 mm ZPU-2 and ZPU-4 LAAG

20 mm M53 LAAG

20 mm M57 LAAG

23 mm (twin) ZU-23 LAAG, and locally built version

23 mm ZSU-23-4 SPAAG (117)

57 mm S-60 AAG

57 mm ZSU-57-2 SPAAG (40)



Thomson-CSF Crotale SAM firing unit of Egyptian Air Defence Command (Egyptian Army)

**EL SALVADOR****Army**

20/3 mm M55 A2 LAAG

40 mm Bofors L/60 AAG (small number)

**ETHIOPIA**

SA-7 'Grail' manportable SAM

4 SA-2 'Guideline' SAM battalions (total 24 launchers)

5 SA-3 'Goa' SAM battalions (total 20 launchers)

14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG

23 mm (twin) ZU-23 LAAG

23 mm ZSU-23-4 SPAAG (60)

37 mm M1939 AAG



SISU XA-180 (6x6) APC of the Finnish Army fitted with Swedish Ericsson Giraffe surveillance radar. The Finnish company of Jantronic OY fitted out this vehicle and also manufactured the radar mast, electric system, heating system, raising and lowering system and additional armouring

## FINLAND

## Army

SA-7 'Grail' manportable SAM (called SAM-78)

SA-14 'Gremlin' manportable SAM and used with Finnish made FCS that includes a surveillance radar

SA-16 'Gimlet' manportable SAM (called 86 Ilga)

3 battalions SA-3 'Goa' SAM (12 × 4-round launchers called SAM-79)

23 mm (twin) ZU-23 LAAG (100+)

35 mm (twin) Oerlikon-Contraves upgraded to GDF-005 standard and used with Super Fledermaus FCS

40 mm Bofors L/60 AAG (has purchased Gather modernisation kits)

40 mm Bofors L/70 AAG (60+)

57 mm S-60 AAG

57 mm ZSU-57-2 SPAAG (12)

Late in 1988, the Finnish MoD placed an order worth FIM75 million (£10 million) for an initial quantity of Marconi Command and Control Systems Marksman twin 35 mm anti-aircraft turrets, training, spares, test equipment and on-site support. The initial contract is for a straight buy but it also includes an option for a further quantity in 1992. The first order was for three turrets which were delivered in 1991.

In 1988 Finland also ordered an improved version of the Thomson-CSF Crotale called Crotale New Generation which in this version will be based on SISU XA-180 (6 × 6) chassis. About 20 systems have been ordered with the first prototype completed late in 1990 and first production systems being delivered in 1991

## FRANCE

## Air Force

400 Mistral launchers, 4000 missiles (total requirement)

24 Crotale SAM acquisition units and 48 firing units

12 Crotale NG shelter units on order

SA-90 SAM under development

20 mm (twin) Cerbere 76T2 LAAG (299)

## Army

FIM-92A Stinger manportable SAM (small number)

500 Mistral launchers + 5000 missiles (total requirement)

30 mm AMX-13 DCA SPAAG (60)

Roland 2 SAM on AMX-30 MBT chassis (181)

3 HAWK SAM regiments with a total of 69 three-round launchers

20 mm (twin) Tarasque 53T2 LAAG

20 mm (single) 53T1 LAAG



French Army Euromissile Roland 2 launching a missile

## GABON

## Army

37 mm M1939 AAG (10) (from China)

In 1988 1 Mygal and 5 Aspic on Panhard VBL 4 × 4 light vehicles were ordered and have been delivered

Kriss (6 × 6) on ERC Sagaie chassis (4)

## GERMANY

## Air Force

FIM-92A Stinger manportable SAM

FIM-43 Redeye manportable SAM



The weapon control system used by Germany (left) and the LuR air surveillance system (right) have both been developed by Deutsche Aerospace and are based on MAN (8 × 8) cross-country trucks and operate in the C-band



Gepard twin 35 mm SPAAG system of the German Army with tracking and surveillance radars retracted (Michael Green/US Army)

## Air Force (continued)

68 Roland SAM on MAN (8 × 8) chassis, delivery 1986 to 1990

2 SA-5 'Gammon' complexes

36 HAWK SAM squadrons (total 216 launchers)

Patriot SAM system, total requirement is 40 squadrons with a total of 320 launchers, of which 12 squadrons will be supplied by US but manned by Germans. The 40 squadrons comprise 2 training squadrons, 2 reduced strength squadrons to act as float units and 6 wings each with 6 missile squadrons

20 mm (twin) Rheinmetall LAAG (1670 systems)

21 fire control and co-ordination systems, first deliveries late 1988 on 8 × 8 MAN chassis. Provides target information to SAM or AAG

**Note:** Air Force SAMs are being organised into six Patriot Groups, nine HAWK Groups and four Shelter Roland Groups

## Army

FIM-92A Stinger manportable SAM (local production now underway with total requirement being for 12 500 missiles)

FIM-43 Redeye manportable SAM

20 mm (single) FK 20-2 (from Norway)

35 mm (twin) Gepard SPAAG (420)

40 mm Bofors L/70 AAG (Super Fledermaus FCS)

144 Roland 2 SAM systems on Marder chassis (3 regiments each with 36 launchers)

## Navy

20 Roland on MAN (8 × 8) chassis, delivery 1988 to 1990

## GHANA

## Army

SA-7 'Grail' manportable SAM



**GREECE****Air Force**

35 mm (twin) Oerlikon-Contraves AAG with Skyguard FCS  
 20 batteries of Skyguard/Sparrow delivered from 1984, called Velos  
 1 group of 36 Nike Hercules SAM launchers

**Army**

FIM-43 Redeye manportable SAM  
 Stinger manportable SAM (member of European consortium making Stinger under licence from USA)  
 2 HAWK SAM battalions (42 launchers)  
 20 mm (twin) Rheinmetall LAAG (200, all forces)  
 30 mm (twin) Artemis AAG, first production systems completed by late 1988, used with fire control system. Some will also be used by Air Force for air base defence  
 40 mm Breda L/70 AAG (50 were built by Breda of Italy and delivered to Greece)  
 40 mm Bofors L/70 AAG (50)  
 40 mm (twin) M42 SPAAG (95 delivered)  
 40 mm M1 AAG, may now be in reserve  
 75 mm M51 (61 supplied) (reserve)  
 90 mm M117 AAG (91 supplied) (reserve)

**GUATEMALA****Army**

20 mm (twin) Oerlikon-Contraves GAI-D01 LAAG  
 40 mm M1 AAG (12)  
 40 mm (twin) M42 SPAAG (small number)

**GUINEA****Army**

SA-7 'Grail' manportable SAM  
 14.5 mm ZPU-4 LAAG  
 30 mm (twin) M53 AAG (unconfirmed user)  
 37 mm M1939 AAG (8) (from China)  
 57 mm S-60 AAG (12)  
 100 mm KS-19 AAG (4)

**GUINEA-BISSAU****Army**

SA-7 'Grail' manportable SAM  
 14.5 mm ZPU-4 LAAG  
 23 mm (twin) ZU-23 LAAG  
 37 mm M1939 AAG (6)  
 57 mm S-60 AAG (12)

**GUYANA****Army**

SA-7 'Grail' manportable SAM

**HAITI****Army**

20 mm (twin) TCM-20 LAAG (6)

**HONDURAS**

20/3 mm M55 A2 LAAG

**HUNGARY****Air Defence Command**

23 mm (twin) ZU-23 LAAG  
 16 battalions SA-2 'Guideline' SAM (96 launchers)  
 6 battalions SA-3 'Goa' SAM (24 launchers)  
 SA-5 'Gammon' SAM

**Army**

SA-7 'Grail' manportable SAM  
 SA-14 'Gremlin' manportable SAM  
 18 SA-4 'Ganef' SAM  
 80 SA-6 'Gainful' SAM  
 44 SA-9 'Gaskin' SAM  
 12 SA-13 'Gopher' SAM  
 14.5 mm ZPU-2 and ZPU-4, not in front line service, also used by militia  
 23 mm (twin) ZU-23 LAAG  
 23 mm ZSU-23-4 SPAAG (14)  
 57 mm S-60 AAG (144)



SA-2 'Guideline' SAMs of the Hungarian Air Defence Command on their resupply trailers being towed by 6 × 6 tractor trucks



ZSU-23-4 self-propelled anti-aircraft guns of the Hungarian Army on parade

**INDIA****Air Force**

25 battalions SA-2 'Guideline' SAM (150 launchers) (being reduced to reserve status)  
 12 battalions SA-3 'Goa' SAM (48 4-round launchers)

**Army**

SA-7 'Grail' manportable SAM  
 SA-14 'Gremlin' manportable SAM  
 40 Tigercat SAM  
 100 SA-6 'Gainful' SAM  
 48 SA-8 'Gecko' SAM  
 200 SA-9 'Gaskin' SAM  
 50+ SA-11 'Gadfly'

The Indian defence research and development organisation is now developing 2 missiles, Akash (Space) medium-range and Trishul (Trident) short-range. Of these Akash was expected to enter service in 1993 and the Trishul in 1991

23 mm (twin) ZU-23 LAAG  
 23 mm ZSU-23-4 SPAAG (75)  
 40 mm Mk 1 AAG used with Super Fledermaus, 1245 believed to be in service but some of these may be US M1 40 mm gun  
 40 mm Bofors L/70 AAG (800+) with Super Fledermaus FCS but being replaced by Flycatcher (first order comprised 40 systems plus option on 212).

**INDONESIA**

20 mm (twin) Rheinmetall LAAG (9)  
 40 mm Bofors L/70 AAG (40) (some used by Marines)  
 Rapier SAM ordered in 1984, 3 orders placed to date  
 RBS 70 surface-to-air missile system plus Giraffe radar system

**IRAN****Air Force**

15 Tigercat SAM (not all operational)  
 Rapier SAM plus Blindfire radars (45 launchers delivered)  
 HQ-2 SAM (Chinese SA-2) reported to be in service (60+ launchers)  
 SA-5 'Gammon' SAM  
 SA-6 'Gainful' SAM  
 23 mm (twin) ZU-23 LAAG  
 40 mm M1 AAG (20 to 40 may still be in service)  
 40 mm Bofors L/70 AAG  
 57 mm S-60 AAG

## Army

FIM-92A Stinger (small number obtained in 1987)  
 SA-7 'Grail' manportable SAM  
 HN-5A manportable SAM  
 RBS 70 surface-to-air missile system  
 37 batteries HAWK SAM (222 launchers) (original number supplied, less than this are now operational)  
 23 mm (twin) ZU-23 LAAG, (and Revolutionary Guard Corps) (300)  
 23 mm ZSU-23-4 SPAAG (100+)  
 35 mm (twin) Oerlikon-Contraves AAG with Skyguard FCS (100)  
 37 mm M1939 AAG (300)  
 40 mm Bofors L/70 AAG  
 57 mm S-60 AAG (200)  
 57 mm ZSU-57-2 SPAAG (80)  
 85 mm KS-12 AAG (unconfirmed user)

**Note:** Much of this equipment is now non-operational due to lack of spare parts

## IRAQ\*

### Air Defence Troops

23 mm (twin) ZU-23 LAAG  
 20 battalions SA-2 'Guideline' SAM (120 launchers)  
 25 battalions SA-3 'Goa' SAM (100 launchers)

## Army

SA-7 'Grail' manportable SAM  
 SA-14 'Gremlin' manportable SAM  
 SA-16 'Gimlet' manportable SAM  
 HN-5A manportable SAM  
 100 SA-6 'Gainful' SAM  
 50 SA-8 'Gecko' SAM  
 100 SA-9 'Gaskin' SAM  
 60 SA-13 'Gopher' SAM  
 Roland 2 SAM AMX-30 (13)  
 Roland 2 SAM shelter (100)  
 14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
 23 mm (twin) ZU-23 LAAG  
 23 mm ZSU-23-4 SPAAG (200+)



*Iraqi SA-8 'Gecko' SAM system (Christopher F Foss)*

## Army (continued)

37 mm M1939 AAG (250)  
 57 mm S-60 AAG (500)  
 57 mm ZSU-57-2 SPAAG (100+)  
 85 mm KS-12 AAG, with Fire Can radar (200)  
 100 mm KS-19 AAG (200)  
 130 mm KS-30 AAG (200)

**\*Note:** These are pre-Gulf War figures, totals have been very much reduced by battle

## IRELAND

### Army

40 mm Bofors L/70 (2)  
 40 mm Bofors L/60 (12)  
 RBS 70 SAM (4)



*Iraqi SA-13 'Gopher' SAM from the rear (Christopher F Foss)*



*Irish Army Bofors RBS 70 SAM (Raymond Maloney)*



*Iraqi SA-2 'Guideline' SAM with nose-mounted infra-red seeker*

## ISRAEL

### Army

FIM-43 Redeye manportable SAM  
 FIM-92A/C Stinger manportable SAM

### Air Force

Chaparral SAM (52)  
 17 battalions HAWK SAM (204 launchers)  
 2 Patriot fire units delivered in 1990 (total of 16 launchers) (more systems expected to be acquired)  
 20 mm Mk I Polsten LAAG  
 20 mm HS-804 LAAG  
 20 mm (twin) TCM-20 LAAG in both towed and self-propelled (half track) configurations, used with Elta EL/M 2106 point defence radar (370)  
 20 mm M167 VADS (towed) (106)  
 20 mm M163 VADS SPAAG (48)  
 23 mm ZSU-23-4 SPAAG (locally modified) (60)





*The Israeli Air Force operates some 15 battalions of Raytheon HAWK SAMs*



*Israeli Chaparral surface-to-air missile system (IDF)*

#### **Air Force (continued)**

23 mm (twin) TCM Mk 3 LAAG on half track  
37 mm M1939 LAAG  
57 mm S-60 AAG  
40 mm Bofors L/70 AAG (Super Fledermaus FCS, upgraded locally)

#### **ITALY**

##### **Air Force**

Spada SAM system with total Army requirement being 4 battalions each with four batteries of six launchers with another four batteries each of four launchers to defend four USAF bases in Italy  
Nike Hercules SAM, 8 groups with a total of 96 launchers, to be replaced by Patriot SAM with requirement being for 20 Patriot battery fire units. Missiles



*Italian Army SIDAM 25 self-propelled anti-aircraft gun system*

#### **Air Force (continued)**

will be provided by Italy, while launchers and radars will be purchased by the US. In return, Italy will provide short-range air defence, including the Spada SAM system, for the protection of key US bases in Italy

#### **Army**

Mistral manportable SAM (selected in 1988 with 600 launchers and 5000 missiles to be made under licence)  
FIM-92B Stinger manportable SAM  
2 regiments of HAWK SAM (60 launchers)  
12.7 mm (quad) M55 LAAG, 109 supplied, status uncertain  
25 mm SIDAM SPAAG (total requirement is for 310 systems of which approximately 100 have been delivered)  
40 mm L/70 AAG, Breda delivered 230 to the Italian Army from 1969

#### **IVORY COAST**

##### **Army**

Panhard M3 VDA SPAAG (6)

#### **JAPAN**

##### **Air Force**

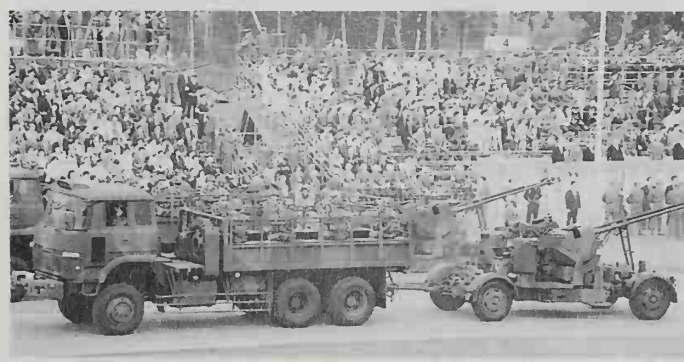
FIM-92A Stinger manportable SAM  
Type 81 Tan-SAM (27 units)  
20 mm M167 Vulcan AAG  
26 Patriot batteries are to be fielded, with two of these ordered direct from the US in 1985 and the remainder made under licence at the rate of about



*Japanese Nike Hercules SAM on semi-trailer (Kensuke Ebata)*



*Japanese Patriot launcher in travelling configuration (Kensuke Ebata)*



*Japanese twin 35 mm Oerlikon-Contrares 35 mm anti-aircraft guns (Kensuke Ebata)*

**Air Force (continued)**

4 batteries each with 5 launchers per year. These will replace Nike Hercules units  
6 groups of 18 squadrons of Nike Hercules (180 launchers), to be replaced by Patriot

**Army**

FIM-92A Stinger manportable SAM  
Type 81 Tan-SAM (47 units)  
32 HAWK SAM batteries (192 launchers)  
12.7 mm (quad) M55, 280 supplied, some still operational for airfield defence  
35 mm Type 87 SPAAG  
35 mm (twin) Oerlikon-Contraves AAG (56) with Super Fledermaus FCS

**JORDAN****Army**

SA-7 'Grail' manportable SAM  
SA-14 'Gremlin' manportable SAM  
FIM-43 Redeye manportable SAM  
Mistral manportable SAM (reported ordered in 1988)  
Javelin manportable SAM (reported)  
14 HAWK SAM batteries (56 launchers)  
12.7 mm (quad) M55 LAAG, 36 supplied  
20 mm M167 VADS  
20 mm M163 VADS (100)  
40 mm (twin) M42 SPAAG (222) (not all operational)

**Air Force**

23 mm ZSU-23-4 SPAAG (44)  
23 SA-8 'Gecko'  
40 SA-13 'Gopher'

**KENYA****Army**

20 mm (twin) TCM-20 LAAG, 50 towed systems in service  
3 Tigercat SAM (first fired in 1987)



Kenya has some 50 Israeli TCM-20 twin 20 mm LAAGs

**KOREA, NORTH****Air Defence Command**

45 SA-2 'Guideline' SAM battalions (270 launchers) some may be HQ-2 from China  
8 SA-3 'Goa' SAM battalions (32 launchers)  
4 SA-5 'Gammon' SAM battalions (24 launchers)

**Army**

HN-5A manportable SAM  
SA-7 'Grail' manportable SAM

**Army (continued)**

14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG which are now locally built and have also been exported (for example, Malta)  
14.5 mm M-1983 SPAAG (tracked chassis fitted with radar-controlled ZPU-4 system which is manufactured in North Korea)  
23 mm (twin) ZU-23 LAAG (1500)  
23 mm ZSU-23-4 SPAAG (100+)  
37 mm M1939 AAG (1000)  
37 mm SPAAG  
57 mm ZSU-57-2 SPAAG (100+)  
57 mm S-60 AAG (600)  
85 mm KS-12 AAG, with Fire Can radar (400)  
100 mm KS-19 AAG (500)

**KOREA, SOUTH****Army**

Shorts Javelin manportable SAM (may involve some local assembly work)  
FIM-92A Stinger manportable SAM  
28 batteries HAWK SAM (168 launchers)  
2 battalions with 10 batteries of Nike Hercules (90 launchers) some used in surface-to-surface role  
12.7 mm (quad) M55 LAAG, locally built, some now mounted on rear of 6 x 6 trucks  
20 mm M167 VADS (towed), local production (66+)  
30 mm twin SPAAG under development. This is called the Flying Tiger and is based on a lengthened Korean Infantry Fighting Vehicle (KIFV) chassis with two-man turret  
35 mm (twin) Oerlikon-Contraves GDF-003 AAG (18+)  
40 mm M1 AAG, 80+ in service  
40 mm Bofors L70 AAG  
Super Fledermaus FCS

**KUWAIT**

In August 1990 Kuwait was occupied by Iraq and equipment captured included 6 batteries of Improved HAWK SAMs (48 launchers), SA-7 manportable SAMs, and 20 SA-8 'Gecko' SAMs. On order at the time of the occupation was a quantity of Amoun air defence systems which consisted of Oerlikon-Skyguard fire control systems, twin 35 mm GDF anti-aircraft guns and Sparrow four-round launchers. Most of the equipment was either destroyed or removed to Iraq during the 1991 war. Kuwait is currently deciding upon replacement systems

**LAOS****Army**

SA-7 'Grail' manportable SAM  
14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
23 mm (twin) ZU-23 LAAG  
23 mm ZSU-23-4 SPAAG (10+)  
37 mm M1939 AAG  
57 mm S-60 AAG

**LEBANON****Army**

20/3 mm M55 A2 LAAG  
23 mm (twin) ZU-23 LAAG  
40 mm (twin) M42 SPAAG (small number)  
M113 APC with ZU-23 LAAG  
M113 APC with ZPU-4 LAAG  
ZSU-23-4 SPAAG

**LIBYA****Air Defence Force**

6 SA-2 'Guideline' SAM brigades (each with 18 launchers)  
9 SA-3 'Goa' SAM brigades (each of 12 launchers)  
6 SA-3 'Goa' SAM battalions (each of 4 launchers)  
6 SA-5 'Gammon' SAM battalions (total of 36 launchers)  
9 Crotale SAM acquisition units and 27 firing units  
50 SA-8 'Gecko' SAM  
23 mm (twin) ZU-23 LAAG

**Army**

SA-7 'Grail' manportable SAM  
160 SA-6 'Gainful' SAM  
40 SA-8 'Gecko' SAM  
60 SA-9 'Gaskin' SAM  
60+ SA-13 'Gopher' SAM  
14.5 mm ZPU-2 and ZPU-4 LAAG  
23 mm (twin) ZU-23 LAAG (100)  
23 mm ZSU-23-4 SPAAG (250)



**Army (continued)**

30 mm M53/59 SPAAG  
40 mm Bofors L/70 AAG (small number?)  
57 mm S-60 AAG (90)

**MADAGASCAR****Army**

14.5 mm ZPU-4 LAAG (50)

**MALAWI****Army**

Blowpipe manportable SAM  
14.5 mm ZPU-4 LAAG (from North Korea)

**MALAYSIA****Army**

SATCP Mistral manportable SAM  
9 Oerlikon-Contrares GDF-005 AAG with Skyguard fire control systems  
40 mm Bofors L/70 AAG (36) (some BOFI)  
Late in 1988 an agreement was signed between the UK and Malaysia for a wide range of defence equipment including 12 Rapier and 48 Javelin SAM launchers plus 2 Marconi Martello radars although it is believed that firm orders for the actual missiles have yet to be placed

**MALI****Army**

12 SA-3 'Goa' SAM launchers  
SA-7 'Grail' SAM  
14.5 mm ZPU-4 LAAG (from North Korea)  
37 mm M1939 AAG (6)  
57 mm S-60 AAG (6)

**MALTA****Army**

14.5 mm ZPU-4 LAAG (50 from North Korea)  
40 mm Bofors L/70 AAG (6)



One of the 50 ZPU-4 14.5 mm LAAGs supplied to Malta by North Korea, shown being used in coast defence/anti-aircraft role

**MAURITANIA****Army**

SA-7 'Grail' manportable SAM  
SA-9 'Gaskin' SAM  
14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
23 mm (twin) ZU-23 LAAG  
37 mm M1939 AAG (20)

**MAURITIUS****Army**

SA-7 'Grail' manportable SAM

**MEXICO****Army**

12.7 mm (quad) M55 LAAG (40 to 50 supplied)

**MONGOLIA****Army**

SA-7 'Grail' manportable SAM  
1 SA-2 'Guideline' SAM battalion (6 launchers)  
14.5 mm ZPU-2 and ZPU-4 LAAG  
23 mm (twin) ZU-23 LAAG  
37 mm M1939 AAG  
57 mm S-60 AAG

**MOROCCO****Army**

SA-7 'Grail' manportable SAM  
37 Chaparral SAM  
14.5 mm ZPU-2 and ZPU-4 LAAG (200 in service)  
20 mm M167 VADS (towed) (70 delivered in early 1980s)  
20 mm M163 VADS SPAAG (60)  
23 mm (twin) ZU-23 LAAG (90)  
37 mm M1939 AAG (25)  
57 mm S-60 AAG (60)  
100 mm KS-19 AAG (? still operational)

**MOZAMBIQUE****Army**

SA-7 'Grail' manportable SAM  
SA-2 'Guideline' SAM (unconfirmed)  
3 battalions SA-3 'Goa' SAM (12 launchers)  
32 SA-9 'Gaskin' SAM  
20/3 mm M55 A2 LAAG  
14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
23 mm (twin) ZU-23 LAAG (120)  
37 mm M1939 AAG  
57 mm ZSU-57-2 SPAAG (20)  
57 mm S-60 AAG (70)

**NEPAL****Army**

40 mm Bofors L/60 AAG (2)  
Reported that China supplied a quantity of LAAG in 1987 and 1988

**NETHERLANDS****Air Force**

40 mm Bofors L/70 AAG (72) with Flycatcher FCS  
12 squadrons of HAWK SAM (72 launchers)  
Patriot SAM, 4 squadrons with a total of 20 launchers and 160 missiles were ordered with first squadron becoming operational in 1987, second in 1988 and remaining 2 in 1990. Last of Nike Hercules SAMs were disbanded in Germany in 1988 and in the same year the Patriot SAM system was declared operational with No 3 and No 5 Guided Missile Groups at Blomberg and Stolzenau in Germany, with each group having 2 squadrons with five 4-round launchers each. Eventually each Group will comprise 2 Patriot and 4 HAWK fire units with Stingers for close defence. By 1990 the Guided Missile Group Netherlands (GMGN) was deployed near major sea and airports in the western Netherlands. At present, the HAWKs defend Dutch air bases but this role will be taken over by a new SAM system (short-range). Four additional Patriot squadrons will be allocated to the GMGN after 1991 at the rate of one squadron a year. Eventually all Patriot units will be brought up to the standard of 8 launchers per unit.  
In April 1989 the Netherlands selected the French Crotale New Generation using the VT-1 missile to meet this requirement, but as of December 1991 no firm orders had been placed for this system. The version selected was the shelter model with Signaal radar.  
Late in 1991 it was announced that the Royal Netherlands Air Force plans to relocate its eight German-based SAM squadrons to De Peel Air Base in The Netherlands. At the same time the Dutch Patriot and Improved HAWK units are to be merged into four composite squadrons.  
The four Patriot and four Improved HAWK squadrons now form part of the 3rd and 5th Netherlands Missile Groups headquartered at Blomberg and Stolzenau as part of the NATO SAM belt in Germany, and will move to the Netherlands in 1994-96.  
The two groups will be merged into one 900 strong group at De Peel comprised of four TRIAD (Triple Air Defence) squadrons. TRIAD integrates Patriot and I-HAWK radar and fire control assets to form a squadron with one Patriot and two Improved HAWK fire platoons and one information co-ordination centre

**Army**

FIM-92A Stinger manportable SAM (member of European consortium making Stinger with total requirement being 90 for Navy/Marines, 944 for Army and 675 for the Air Force)  
35 mm (twin) SPAAG (95)

**Army (continued)**

40 mm Bofors L/70 AAG (60) with Flycatcher FCS. Late in 1987 it was announced that these would be upgraded, 6 being done by Bofors in Sweden and the remainder by RDM in the Netherlands. Early in 1987 30 Flycatcher FCS were ordered, 27 for use by 3 L/70 units in Germany and 3 in reserve. All were delivered by 1990

**NICARAGUA****Army**

SA-7 'Grail' manportable SAM  
SA-14 'Gremlin' manportable SAM  
SA-16 'Gimlet' manportable SAM  
12 SA-9 'Gaskin' SAM  
14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG (100 in service)  
20 mm GAI-C01 LAAG  
23 mm (twin) ZU-23 LAAG  
37 mm M1939 AAG (56)  
57 mm S-60 AAG  
100 mm KS-19 AAG

**NIGERIA**

SA-7 'Grail' manportable SAM  
Blowpipe manportable SAM  
Roland 2 SAM on AMX-30 chassis (16)  
23 mm ZSU-23-4 SPAAG (30)

**NORWAY****Air Force**

6 batteries of Improved HAWK NOAH SAM (54 launchers)  
1 battalion of Nike Hercules with 2 batteries, total 12 launchers, being replaced by NASAMS  
40 mm M1 AAG (32)  
40 mm Bofors L/70 AAG (64), Super Fledermaus FCS, being upgraded by SATT  
40 mm Bofors L/60 AAG (32), Super Fledermaus FCS, being upgraded by SATT  
In January 1989 contracts were signed for the Norwegian Advanced SAM System (NASAMS) which will replace remaining Nike Hercules missiles. In September 1989 the Norwegian Air Force placed an order worth over MSEK800 for RBS 70 systems for air base defence with deliveries to run from 1991 through to 1994. These will use the new Mk 2 missile and replace current 40 mm L/60 anti-aircraft gun systems

**Army**

RBS 70 SAM used with Giraffe radar (first order was for 110 launchers plus 27 radars)  
12.7 mm (quad) M55, some used for airfield defence  
20 mm (single) FK 20-2 LAAG  
40 mm M1 AAG, (132 supplied but some in reserve)  
40 mm Bofors L/60 AAG  
In 1989 the Norwegian Army Material Command awarded a \$90 million contract to Ericsson Radar Electronics of Sweden for Giraffe 50AT mobile search radar and C<sup>3</sup>I systems for use in the Norwegian Army Low Level Air Defence System (NALLADS)

**OMAN****Air Force**

2 squadrons of Rapier ordered in 1974 and delivered from 1977, Blindfire radars ordered in 1980; 28 launchers purchased, 24 operational, remainder training/war reserve. These are operated by Nos 10 and 12 Squadrons SOAF

**Army**

Blowpipe manportable SAM  
Javelin manportable SAM  
23 mm (twin) ZU-23 LAAG

**National Guard**

20 mm (twin) SPAAG on VAB (6 × 6) chassis (9)



Omani National Guard VAB (6 × 6) vehicles fitted with TA-20 twin 20 mm anti-aircraft turret

**PAKISTAN****Air Force**

12 Crotale acquisition units and 24 firing units  
1 battalion of HQ-2 SAM (from China 6 launchers)

**Army**

HN-5A manportable SAM  
Blowpipe manportable SAM  
FIM-92A Stinger SAM  
RBS 70 SAM, plus Giraffe radars  
12.7 mm (quad) M55 LAAG, 45+ supplied  
14.5 mm ZPU-2 and ZPU-4 LAAG (from China)  
23 mm (twin) ZU-23 LAAG (from China)  
35 mm (twin) Oerlikon-Contraves AAG (also used for airfield defence) (up to 100 have been ordered with Skyguard FCS)  
37 mm (twin) AAG (from China) (700) (same as M1939 of USSR) competition to provide new FCS underway  
40 mm Mk 1 AAG  
40 mm M1 AAG (60)  
57 mm S-60 AAG (from China)  
90 mm M117 (15 supplied and now in reserve)  
Anzi manportable SAM  
Anzi/14.5 mm SPAAG system



Stinger manportable SAM in service with Pakistani Army

**PANAMA**

14.5 mm ZPU-4 LAAG

**PARAGUAY**

40 mm M1 AAG (12)

**PERU****Air Force**

3 battalions of SA-3 'Goa' SAM (12 launchers)

**Army**

SA-7 'Grail' manportable SAM  
23 mm (twin) ZU-23 LAAG  
23 mm ZSU-23-4 SPAAG (35)  
40 mm M1 AAG (28)  
40 mm Bofors L/60 AAG (40)  
40 mm Bofors L/70 AAG (40)

**POLAND****Air Defence Command**

40 battalions SA-2 'Guideline' SAM (240 launchers)  
50 battalions SA-3 'Goa' SAM (200 launchers)  
23 mm (twin) ZU-23 LAAG

**Army**

SA-7 'Grail' manportable SAM  
SA-14 'Gremlin' manportable SAM  
100 SA-6 'Gainful' SAM  
60 SA-8 'Gecko' SAM  
200 SA-9 'Gaskin' SAM  
20+ SA-11 'Gadfly' SAM  
SA-13 'Gopher' SAM  
14.5 mm ZPU-2 and ZPU-4 LAAG, not in front line service, also used by Troops of Territorial Defence



**Army (continued)**

23 mm (twin) ZU-23 LAAG, also used by Troops of Territorial Defence (1242)  
 23 mm ZSU-23-4 SPAAG (87)  
 57 mm S-60 AAG (144)

**PORTUGAL****Air Force**

1 Improved HAWK battery

**Army**

Blowpipe manportable SAM  
 5 Chaparral SAM delivered in 1987  
 12.7 mm (quad) M55 LAAG (18)  
 20 mm M163 VADS SPAAG (36 ordered in 1987)  
 20 mm (twin) Rheinmetall LAAG, 36 believed used by Army  
 40 mm Bofors L/60 AAG (80) (Army and Air Force)

**QATAR****Army**

Rapier SAM, 12 ordered in 1981, also has Blindfire radar  
 Blowpipe manportable SAM  
 Stinger FIM-92A manportable SAM  
 Mistral manportable SAM  
 5 Tigercat SAM (1 battery)  
 3 Roland 2 on AMX-30 chassis  
 6 Roland 2 shelter on 8 x 8 MAN chassis

**ROMANIA****Air Force**

18 battalions SA-2 'Guideline' SAM (108 launchers)

**Army**

SA-7 'Grail' manportable SAM  
 60 SA-6 'Gainful' SAM  
 40 SA-9 'Gaskin' SAM  
 14.5 mm ZPU-2 and ZPU-4 LAAG, also used by MoD Security Troops, Patriotic Guard and Border Troops  
 23 mm ZSU-23-4 SPAAG (50) (unconfirmed)  
 30 mm (twin) M53 AAG (300)  
 2 x 30 mm LAAG (local design)  
 37 mm M1939 AAG (100)  
 57 mm S-60 AAG (150)  
 57 mm ZSU-57-2 SPAAG (60)  
 85 mm KS-12 AAG, with Fire Can radar (75)  
 100 mm KS-19 AAG (30)

**SAO TOMÉ & PRINCIPE****Army**

14.5 mm ZPU-4 LAAG

**SAUDI ARABIA****Air Force**

16 Crotale SAM acquisition units and 48 Crotale firing units  
 16 batteries HAWK SAM (126 launchers)  
 6 Patriot fire units delivered from late 1990, further 6 fire units for delivery from 1993 with a requirement for another 14 fire units and 700 missiles



Saudi Arabian National Guard is sole user of Commando V-150 fitted with Vulcan 20 mm air defence system

**Air Force (continued)**

required for delivery in the late 1990s, although as of November 1991 the latter order had not been submitted to Congress  
 35 mm Oerlikon-Contraves AAG with Skyguard FCS

**Army**

FIM-92A Stinger manportable SAM  
 FIM-43 Redeye manportable SAM  
 Mistral manportable SAM  
 36 Shahine SAM acquisition units on AMX-30 chassis  
 73 Shahine SAM firing units on AMX-30 chassis  
 10 Shahine SAM acquisition units shelter-mounted  
 19 Shahine SAM firing units shelter-mounted  
 20 mm M163 VADS SPAAG (20 VADS on V-150 Commando operated by National Guard)  
 30 mm (twin) AMX-30 DCA SPAAG (53)  
 35 mm (twin) Oerlikon-Contraves AAG with Skyguard FCS (up to 200 may be in service, some used by Air Force for airfield defence)  
 40 mm Bofors L/70 (with BOFI) (72 systems delivered from Spain)

**SENEGAL**

21 20 mm 53T2 LAAG  
 12 40 mm L/60 LAAG

**SEYCHELLES****Army**

SA-7 'Grail' manportable SAM  
 14.5 mm ZPU-4 LAAG

**SIERRA LEONE****Army**

SA-7 'Grail' manportable SAM

**SINGAPORE****Air Force**

20 mm GAI-C01 LAAG  
 35 mm (twin) Oerlikon-Contraves GDF-002 AAG with Super Fledermaus FCS, but upgraded with SATT modernisation package (34)  
 40 mm Bofors L/60 AAG (16)  
 RBS 70 SAM (1 squadron) mounted on Commando V-200 (4 x 4) armoured car  
 1 squadron of Rapier 12 SAM ordered in 1981, also uses 6 Blindfire  
 1 squadron of HAWK SAM (18 launchers)  
 SATCP Mistral manportable SAM  
 Crotale NG SAM believed to be on order

**Army**

RBS 70 SAM

**SOMALIA****Air Defence Forces**

7 battalions SA-2 'Guideline' SAM (42 launchers) (these may no longer be operational)  
 2 battalions SA-3 'Goa' SAM (8 launchers)

**Army**

FIM-43 Redeye manportable SAM  
 SA-7 'Grail' manportable SAM  
 14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
 20 mm M167 VADS (towed)  
 20 mm (twin) Cerbere 76T2 LAAG (40)  
 23 mm (twin) ZU-23 LAAG (50)  
 23 mm ZSU-23-4 SPAAG (4)  
 37 mm M1939 AAG (180)  
 57 mm S-60 AAG (20)  
 100 mm KS-19 AAG (24)

**SOUTH AFRICA****Air Force**

7 Crotale SAM acquisition and 14 Crotale firing units

**Army**

20 mm (single) SPAAG called the Ystervark. This is an armoured SAMIL 20 (4 x 4) truck fitted with an Oerlikon-Contraves 20 mm GAI-C01 cannon on the rear  
 20 mm (single) Oerlikon-Contraves GAI-C04 and GAI-C01 LAAG  
 20 mm (single) Oerlikon-Contraves GAI-B01 LAAG  
 35 mm twin Oerlikon-Contraves GDF-002 AAG (150) with Super Fledermaus FCS  
 40 mm Bofors L/60 (reserve)  
 LPD-20 radars

## SPAIN

## Army

Mistral manportable SAM. In January 1992 Spain ordered 200 SATCP firing posts and 800+ Mistral rounds under a co-production agreement. Deliveries will be made to the Spanish Army and Marines.

6 batteries of Toledo air defence systems, each has 1 Skyguard fire control system, 2 twin Oerlikon-Contraves 35 mm GDF-005 anti-aircraft guns and two 4-round Spada SAM launchers

2 battalions HAWK SAM (24 launchers)

1 battery Nike Hercules SAM (9 launchers)

12.7 mm (quad) M55 LAAG, 132 supplied, some have been mounted on rear of 6 x 6 truck, also used by Marines (in Army may have been replaced by 20 mm cannon)

20 mm (single) Oerlikon-Contraves GAI-B01 LAAG

35 mm (twin) Oerlikon-Contraves GDF-002 AAG (96) with Super Fledermaus and Skyguard FCS

40 mm Bofors L/70, 243 were built under licence in Spain by SA Placencia de las Armas, getting FELIS FCS

18 Roland SAM systems on Spanish built AMX-30E chassis and 414 missiles ordered in 1984 with first of these being delivered in November 1988. Of these, 9 are clear weather systems and 9 all-weather. Used by 71st Independent Air Defence Regiment

90 mm M117 AAG (40 supplied and now in reserve)

## SRI LANKA

## Army

24 3.7 in (94 mm) AAG may be in service

## SUDAN

SA-7 'Grail' manportable SAM

FIM-43 Redeye manportable SAM

5 battalions SA-2 'Guideline' SAM (30 launchers) (may now be non-operational)

14.5 mm ZPU-2 and ZPU-4 LAAG

20 mm M163 VADS SPAAG (8) (delivered 1981/1982)

20 mm M167 VADS (towed)

23 mm (twin) ZU-23 LAAG (from Egypt)

37 mm M1939 AAG (120)

40 mm Bofors L/60 AAG (60, ? still operational)

85 mm KS-12 AAG, with Fire Can radar

100 mm KS-19 AAG



Swedish Army using Ericsson Giraffe radar system to provide early warning and control facility to its RBS 70 SAMs

## SWEDEN

## Army

RBS 70 SAM system with Giraffe radar

RBS 90 SAM on order under a contract signed in 1989 worth over MSEK550 with first deliveries in 1991

Lvrbv 701 vehicle-mounted RBS 70 system

1 HAWK SAM battalion (12 launchers) (called Rb 67)

20 mm LAAG

40 mm Bofors L/60 AAG

40 mm Bofors L/70 AAG



The Ericsson HARD 3D radar system is a key part of the new RBS 90 system in production for the Swedish Army

## SWITZERLAND

## Air Force

2 Bloodhound (BL-64) SAM squadrons, each with 32 launchers

35 mm (twin) Oerlikon-Contraves AAG (see Army)

## Army

FIM-92 RMP Stinger manportable SAM (in 1988 the Swiss MoD announced that it would acquire a minimum of 2500 missiles valued at \$315 million) Rapier SAM, 60 launchers in service plus Blindfire radars, final deliveries 1986

20 mm (single) Oerlikon-Contraves GAI-B01 AAG (1700)

35 mm (twin) Oerlikon-Contraves AAG (264) (used by Army and Air Force with Super Fledermaus and Skyguard FCS) (108 to be upgraded with new NDF-C modernisation kit)

## SYRIA

## Air Defence Command

40 battalions SA-2 'Guideline' SAM (138 launchers)

23 battalions SA-3 'Goa' SAM (160 launchers)

4 battalions SA-5 'Gammon' SAM (24 launchers)

27 battalions SA-6 'Gainful' SAM (108 launchers)

23 mm (twin) ZU-23 LAAG

130 mm KS-30 AAG (reserve)

## Army

SA-7 'Grail' manportable SAM

SA-14 'Gremlin' manportable SAM

150 SA-9 'Gaskin' SAM

50 SA-6 'Gainful' SAM

160 SA-8 'Gecko' SAM

40+ SA-9 'Gaskin' SAM

20+ SA-11 'Gadfly' SAM

60 SA-13 'Gopher' SAM

12.7 mm M53 LAAG (reserve and militia)

14.5 mm ZPU-2 and ZPU-4 LAAG, but not in front line service, also used by militia

20 mm Hispano-Suiza LAAG (single barrel)

20 mm Hispano-Suiza LAAG (triple barrel)

23 mm (twin) ZU-23 LAAG

23 mm ZSU-23-4 SPAAG (300)

30 mm Hispano-Suiza HS-661 LAAG

37 mm M1939 AAG

57 mm ZSU-57-2 SPAAG (100+)

57 mm S-60 AAG

85 mm KS-12 AAG, with Fire Can radar

100 mm KS-19 AAG





*Chaparral SAM used by Taiwan (L J Lamb)*



*HAWK SAMs of Taiwan on their M390C trailer (L J Lamb)*



*Radar set, CW, illuminator, AN/MPQ-33 mounted on M514 trailer as used by Taiwan (L J Lamb)*

## TAIWAN

### Army

Tien Kung I SAM  
Tien Kung II SAM  
Sky Sword I SAM (under development)  
13 HAWK SAM battalions (78 launchers)  
2 Nike Hercules battalions (36 launchers)  
Chaparral SAM (52)  
12.7 mm (quad) M55 LAAG

### Army (continued)

35 mm (twin) Oerlikon-Contraves GDF AAG and Skyguard FCS  
40 mm M1 AAG (200)  
40 mm Bofors L/70 AA (use unconfirmed)  
40 mm (twin) M42 SPAAG (295 delivered)

## TANZANIA

### Army

SA-7 'Grail' manportable SAM  
2 SA-3 'Goa' battalions (8 launchers)  
12 SA-6 'Gainful' SAM  
40 SA-9 'Gaskin' SAM  
14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG (160/240)  
23 mm (twin) ZU-23 LAAG  
37 mm Type 55 AAG (120) (from China)

## THAILAND

### Air Force

Blowpipe manportable SAM  
One Spada SAM battery delivered in 1988 (4 four-round launchers)  
Crotale NG shelter version on order  
20 mm M39 (twin and triple LAAG)  
20 mm M163 VADS SPAAG (24)  
30 mm (twin) Arrow AAG, first deliveries 1988 used with Oerlikon-Contraves Skyguard FCS  
37 mm (twin) Type 74 AAGs supplied by China in 1987-88 (40)  
40 mm M1 AAG (80)  
40 mm Bofors L/70 AAG (48 delivered from UK in 1987)  
40 mm (twin) M42 SPAAG (16)

### Army

FIM-43 Redeye manportable SAM  
Crotale NG tracked version on order  
12.7 mm (quad) M55 LAAG  
20 mm M167A1 VADS (towed) (24 ordered in 1982)



*M163A1 Vulcan 20 mm self-propelled air defence system of the Royal Thai Army with shelter-mounted radar system on 6 x 6 2.5 ton (US) truck in background*

## TOGO

### Army

14.5 mm ZPU-4 LAAG (38 from North Korea)  
37 mm M1939 AAG (6)

## TUNISIA

### Army

60 RBS 70 Launchers and 12 Giraffe radars  
Chaparral SAM (26)  
37 mm Type 55 (M1939) AAG (10) (from China)  
40 mm (twin) M42 SPAAG (12)

## TURKEY

### Air Force

72 Rapier SAM also uses Blindfire  
8 squadrons of Nike Hercules SAM each with 9 launchers (total 72 launchers)

**Army**

FIM-92A Stinger manportable SAM (member of European consortium making Stinger with total Turkish requirement being for 4500 missiles)  
 FIM-43 Redeye manportable SAM  
 12.7 mm (quad) M55 LAAG (160)  
 20 mm (twin) GAI-D01 LAAG (licensed production)  
 35 mm (twin) Oerlikon-Contraves GDF AAG (250 ordered with Gun King) (believed licensed production). There is also a competition for a fire control system to go with these weapons with the contenders including the Marconi Radar and Control Systems Apache, Signaal Flycatcher and the Contraves Skyguard  
 40 mm M1 AAG (300)  
 40 mm Bofors L/70 AAG (also Air Force)  
 40 mm (twin) M42 SPAAG (100)  
 75 mm M51 AAG (110 delivered)  
 90 mm M117 AAG (116 delivered)  
 90 mm M118 AAG (above figures include this version)  
 The Turkish Army has a requirement for a new low level air defence system and in late 1988 the choice was narrowed to 3; ADATS, Crotale New Generation and Roland, but as of December 1991 none of these had been selected  
 Super Fledermaus FCS

**UGANDA****Army**

SA-7 'Grail' manportable SAM system  
 14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
 23 mm (twin) ZU-23 LAAG (20+)  
 37 mm M1939 AAG (20)

**USSR****Air Defence Troops**

SA-1 'Guild' SAM (1600 launchers, being reduced)  
 SA-2 'Guideline' SAM (2400 launchers)  
 SA-3 'Goa' SAM (1250 launchers at 300 sites)  
 SA-5 'Gammon' SAM (1950 launchers at 130 sites)  
 SA-10a/b 'Grumble' SAM  
 SA-12a/b 'Gladiator'/'Giant' SAM  
 23 mm (twin) ZU-23 LAAG  
 57 mm S-60 AAG  
 85 mm KS-12 AAG (reserve)  
 100 mm KS-19 AAG (reserve)  
 130 mm KS-30 AAG (reserve)

**Naval Infantry**

SA-7 'Grail' manportable SAM  
 SA-8 'Gecko' SAM  
 SA-9 'Gaskin' SAM  
 SA-13 'Gopher' SAM  
 SA-14 'Gremlin' manportable SAM  
 SA-16 'Gimlet' manportable SAM  
 SA-19 manportable SAM  
 23 mm ZSU-23-4 SPAAG

**Army**

SA-4 'Ganef' SAM (1300)  
 SA-6 'Gainful' SAM (850)  
 SA-7 'Grail' manportable SAM  
 SA-8 'Gecko' SAM (1000+)  
 SA-9 'Gaskin' SAM (450)  
 SA-10 'Grumble' SAM (1500)  
 SA-11 'Gadfly' SAM  
 SA-12a 'Gladiator' SAM  
 SA-13 'Gopher' SAM (1200)  
 SA-14 'Gremlin' manportable SAM  
 SA-15 SAM  
 SA-16 'Gimlet' manportable SAM



Although the P-25 Bar Lock early warning radar is an old design it still remains in service with the Soviet Union and many other countries

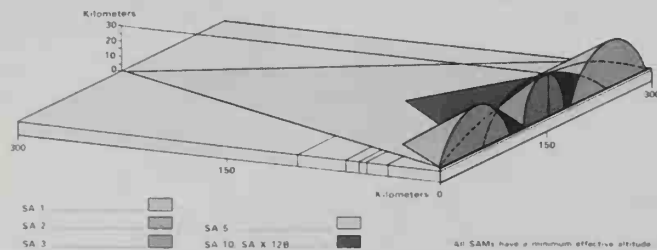


SA-6 'Gainful' SAM systems of the Soviet Army

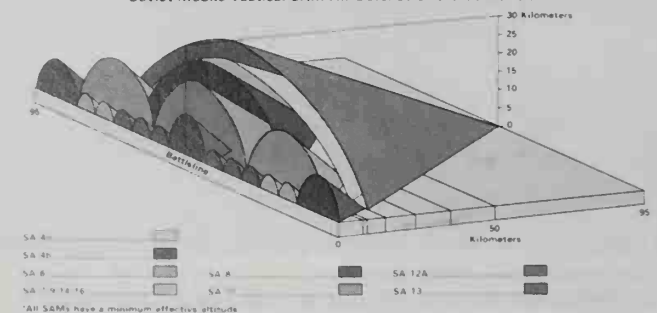


SA-3 'Goa' SAM system of the Soviet Army

Soviet Strategic SAM Air Defense Barrier Illustrated from Fixed Sites'



Soviet Mobile Tactical SAM Air Defense of the Battlefield'





**Army (continued)**

SA-19 manportable SAM

SA-X-17 SAM

14.5 mm ZPU-1, ZPU-2 and ZPU-4, not in front line service, also used by

KGB, MVD, militia and Naval Infantry (reserve)

23 mm (twin) ZU-23 LAAG, also used by KGB, MVD and militia

23 mm ZSU-23-4 SPAAG

2S6 SPAAG/SAM systems

37 mm M1939 AAG (reserves and militia)

57 mm ZSU-57-2 SPAAG (mainly reserve)

57 mm S-60 AAG

**UNITED ARAB EMIRATES****Air Force**

5 HAWK SAM batteries (30 launchers)

**Army**

RBS 70 SAM delivered from 1980 onwards

Rapier SAM ordered by Abu Dhabi in 1974, later ordered Blindfire radars

3 Crotale SAM acquisition and 9 Crotale firing units

20 mm (twin) Panhard M3 VDA SPAAG (42)

35 mm (twin) Oerlikon-Contraves GDF series AAG (30) with Skyguard FCS

20 mm M55A2 LAAG

Javelin manportable SAM (Dubai)

**UNITED KINGDOM****Air Force**

35 mm (twin) Oerlikon-Contraves GDF series AAG (12) with Skyguard FCS (captured from Argentina in Falklands)

Rapier SAM, 7 squadrons, 4 in Germany and 3 in UK, Blindfire radar issued on scale of 1 per launcher



British Aerospace Rapier SAM system defending an RAF airfield. Marconi Radar and Control Systems Blindfire radar (left), optical tracker (centre) and four-round launcher (right)



Twin 35 mm Oerlikon-Contraves anti-aircraft gun of No 2729 Squadron, Royal Auxiliary Air Force Regiment, in action and being controlled by Marconi Command and Control Systems Apache FCS



THORN EMI Air Defence Alert Device in tripod-mounted configuration providing target information for manportable version of Shorts Starstreak HVM missile system. The ADAD will also be fitted to the Shorts Starstreak HVM system mounted on the Alvis Stormer vehicle to enter service with the British Army in the early 1990s

**Army**

Rapier SAM, 3 regiments (2 in BAOR, 1 in UK), plus Blindfire radars (but on 1 per 2 launcher basis and issued as required). Rapier is also deployed in Belize (4) (RAF) and Falkland Islands (RAF). Army is getting Rapier Darkfire while RAF will wait for Rapier 2000 which will also go to British Army. By the mid-1990s the British Army will have two Rapier and two Starstreak HVM air defence regiments

130 to 150 Starstreak SPAAM on order

Tracked Rapier SAM (72) (to be phased out of service by mid-1990s)

Blowpipe manportable SAM (TA only)

Javelin manportable SAM (Army and TA)

Starburst manportable SAM (Army)

FIM-92A Stinger manportable SAM (SAS)

**Marines**

Shorts Javelin manportable SAM

**UNITED STATES OF AMERICA****Air Force**

FIM-92A/B/C Stinger manportable SAM

27 Roland SAM on MAN (8 x 8) chassis in FGR, manned by Germany and delivered 1987 to 1989

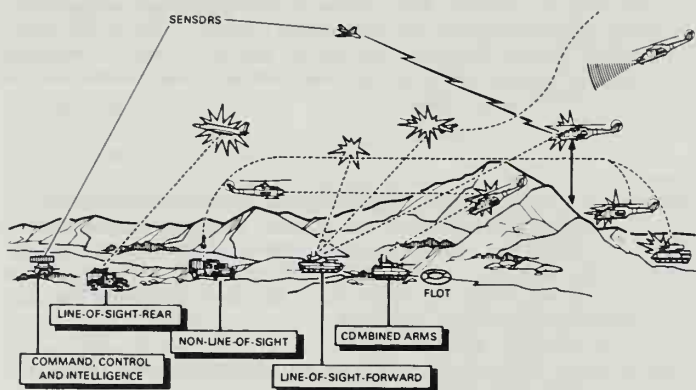
Rapier SAM plus Blindfire radar (1 per launcher), 14 in Turkey manned by Turkish military personnel, 32 in UK manned by Royal Air Force Regiment to protect USAF basis, (28 launchers operational and remaining 4 for training)



ADATS on M3 Bradley undergoing trials in the United States



12 Forward Area Alerting Radar (FAAR) systems being delivered to the US Army early in 1991 by Sanders Defense Systems Division for deployment to the Middle East



Main components of US Army's Forward Area Air Defense (FAAD) system (US Army)

**Note:** The FOG-M system, developed to meet the NLOS requirement was cancelled in December 1990 by US Army, but reinstated in mid-1991 for the anti-armour role

#### Army

FIM-43 Redeye manportable SAM (training)  
FIM-92A/B/C Stinger manportable SAM (by FY85 a total of 11 650 Stingers had been procured with the total procurement objective being 50 664 missiles)  
Pedestal-Mounted Stinger, 20 ordered in 1987 with deliveries late 1988, requirement for 173 systems over 5 year period with total requirement to be 1200 units  
523 Chaparral SAMs, being improved. The National Guard is replacing its M42 SPAAGs with Chaparral SAM and by early 1989 five battalions were operational (New Mexico, Ohio, Florida, South Carolina and North Dakota with the 6th, in Arkansas due to become operational in FY91)  
ADATS, 4 ordered with FY88 funding, total requirement 360  
20 mm M167 VADS (towed) AAG (some upgraded to PIVADS) (being phased out of service)  
20 mm M163 VADS SPAAG (360) (some upgraded to PIVADS) (being phased out of service)  
Improved HAWK, 7 regular battalions plus 4 National Guard (4th operational in FY91)  
Raytheon Patriot SAM, total procurement objective is 104 fire units (batteries) of which 58 had been procured through FY85 with 3 of these procured with NATO air base air defence funds. Of these 84 will be in the field and remainder for training and war reserve. A total of 7 battalions are deployed in Europe and 3 retained in the USA

#### Marine Corps

FIM-92A/B/C Stinger manportable SAM  
3 battalions of Improved HAWK SAM of which 2 are regular and 1 reserve

#### Navy

FIM-92A/B/C Stinger manportable SAM

#### URUGUAY

##### Army

20 mm M167 VADS (towed)  
40 mm Bofors L/60 (2)

#### VENEZUELA

##### Army

36 40 mm (twin) Breda 40L70 field mountings were delivered in early 1980s and these, together with 18 Signaal Flycatcher radar FCS, form the Guardian air defence system  
40 mm Bofors L/70 AAG (18)  
40 mm Bofors L/60 AAG (60 but some may be L/70)  
6 Roland 2 SAM shelter-mounted  
RBS 70 surface-to-air missile system

##### Marines

40 mm (twin) M42 SPAAG (30)



Venezuela is the only user of the Breda 40 mm (twin) 40L70 field mounts which are used in conjunction with Flycatcher FCS

#### VIETNAM

##### Air Defence Forces

20 regiments SA-2 'Guideline' (each with 18 launchers)  
10 SA-3 'Goa' regiments (total 160 launchers)  
85 mm KS-12 AAG  
100 mm KS-19 AAG  
130 mm KS-30 AAG

##### Army

SA-7 'Grail' manportable SAM  
80 SA-6 'Gainful' SAM  
100+ SA-9 'Gaskin' SAM  
12.7 mm (quad) M53 AAG, probably now held in reserve  
14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG  
23 mm (twin) ZU-23 LAAG (900)  
23 mm ZSU-23-4 SPAAG (100+)  
30 mm (twin) M53 AAG, probably now held in reserve (150)  
37 mm M1939 AAG  
57 mm ZSU-57-2 SPAAG (50+)  
57 mm S-60 AAG

#### YEMEN

2 battalions SA-2 'Guideline' SAM (12 launchers)  
3 battalions SA-3 'Goa' SAM (12 launchers)  
SA-6 'Gainful' SAM (40)  
SA-7 'Grail' manportable SAM  
20+ SA-9 'Gaskin' SAM  
20 mm M163 VADS (20)  
23 mm (twin) ZU-23 LAAG  
23 mm ZSU-23-4 SPAAG (50+)  
37 mm M1939 AAG (30)  
57 mm S-60 AAG (100)  
85 mm KS-12 AAG, with Fire Can radar (20)

#### YUGOSLAVIA\*

##### Protective Air Defence Force

8 battalions SA-2 'Guideline' SAM (48 launchers)  
6 battalions SA-3 'Goa' SAM (24 launchers)  
SA-11 'Gadfly' SAM



**Protective Air Defence Force (continued)**

SA-6 'Gainful' SAM

SA-9 'Gaskin' SAM

Above 3 form total of 6 regiments

**Army**

SA-7 'Grail' manportable SAM (plus locally improved model)

80 SA-6 'Gainful' SAM

20 SA-8 'Gecko' SAM

100 SA-9 'Gaskin' SAM

20/3 mm M55 A2 LAAG

20/3 mm M55 A3 B1 LAAG

20/3 mm M55 A4 B1 LAAG

20/1 mm M75 LAAG

20 mm BOV-3 SPAAG

30 mm (twin) M53 AAG, probably now held in reserve

30 mm M53/59 SPAAG

30 mm (twin) BOV SPAAG

37 mm M1939 AAG (400)

40 mm Bofors L/70 AAG (some of which are BOFI)

40 mm AAG, both UK Mk 1 and US M1 have been in service, but present status of these is uncertain, some sources state 128 40 mm M1s supplied

57 mm S-60 AAG (250)

57 mm ZSU-57-2 SPAAG (50+)

85 mm KS-12 AAG, with Fire Can radar (260)

90 mm M117 AAG (210), probably now non-operational

3.7 in (94 mm) AAGs are now believed to have been phased out of service

**\*Note:** These are pre-disturbance figures, many weapons are being used by various factions in inter-state conflicts in both air defence and ground roles

**ZAIRE****Army**

14.5 mm ZPU-4 LAAG

37 mm M1939 AAG

40 mm Bofors L/60 AAG (status uncertain)

**ZAMBIA****Air Force**

1 SA-3 'Goa' battalion of 3 batteries (12 launchers)

**Army**

SA-7 'Grail' manportable SAM

14.5 mm ZPU-4 LAAG

20 mm M75 LAAG

37 mm M1939 AAG (40)

57 mm S-60 AAG (55)

85 mm KS-12 AAG with Fire Can radar (16)

**ZIMBABWE****Army**

SA-7 'Grail' manportable SAM

14.5 mm ZPU-1, ZPU-2 and ZPU-4 LAAG

20/3 mm M55 A2 AAG

23 mm (twin) ZU-23 LAAG

37 mm M1939 AAG

# Addenda

## SOUTH AFRICA

### ARMSCOR ZA-35 Twin 35 mm Self-propelled Anti-aircraft Gun

#### Development

At present the only self-propelled anti-aircraft gun (SPAAG) in service with the South African Army is the Ystervark 20 mm system mounted on a modified Buffel (4 × 4) vehicle.

The Ystervark was successfully used in Namibia but has a number of major tactical disadvantages in that it cannot operate with the higher mobility 6 × 6 and 8 × 8 vehicles used by the army, its 20 mm cannon has a short effective range and low rate of fire and it has no fire control system.

In 1983 the South African Army produced a requirement for an air defence system to provide close air defence of its mechanised battle groups.

A number of foreign systems in development or production were studied to meet this requirement, but these were all considered to be too expensive even if they could have been purchased by South Africa and they did not provide the required kill probability against low flying aircraft and helicopters.

It was decided that a 35 mm cannon would be the best calibre to engage targets at ranges of up to 3500 to 4000 m and development of a new 35 mm cannon was authorised.

Prime contractor for the new 35 mm cannon, designated the M-35, is the Lyttleton Engineering Works (LEW), part of the ARMSCOR Group and home of the G5 and G6 155 mm artillery systems.

The M-35 is a fully automatic, gas-operated, open-breech, belt fed cannon that fires mechanically primed ammunition. Its design is such that it is easy to maintain under field conditions without any special tools and this ensures maximum availability and reduced life cycle costs. It has fewer parts than the 35 mm KDA cannon used in the Gepard SPAAG.

The independent gas-operated ammunition feed system ensures that the rate of fire (cyclic rate of fire is 500 to 600 rounds per barrel per minute) is not affected by the ammunition belt length or tension. The cannon is cocked by a hydraulic mechanism and has 55 mm of recoil.

The open-breech mechanism prevents the possibility of self-ignition of ammunition and the gun controller allows for pre-programmable burst lengths or single-shot option for engaging ground or aerial targets.

The M-35 cannon can fire the following types of 35 mm ammunition that are already manufactured in South Africa by Pretoria Metal Pressings (PMP), also part of the ARMSCOR Group, these include HEI, HEI-T, SAPHEI, APCI-T, PRAC and PRACT-T.

Although the first application of the M-35 is the ZA-35 SPAAG, the design of the weapon is such that it has a number of applications. The linked ammunition is fed by either single or double feeder system via flexible or fixed ammunition chutes from either the horizontal or vertical positions, so facilitating various mounting applications. The M-35 cannon could be fitted with a muzzle velocity sensor which would feed information into a central computer.

Studies of a self-propelled anti-aircraft gun (SPAAG) system commenced in 1983 with full-scale development of the ZA-35 twin 35 mm SPAAG commencing in 1986 with the first turret and hull being completed in 1990 with full system integration taking place in 1991.

So far one complete prototype has been built but it is understood that following the changing situation in South Africa and that there is no longer considered to be an external threat, no funding has been made available for production ZA-35 systems.

Prime contractor for the ZA-35 is Kentron, a subsidiary of ARMSCOR and known mainly for their missile programmes with major subcontractors being LEW (turret), ESD (radar) and Synertech (computer).

#### Description

The ZA-35 is based on a slightly modified Rooikat (8 × 8) armoured car chassis which is already in production and service with the South African Armoured Corps. The chassis is manufactured by Sandock-Austral, a private sector company with many years experience in the development and production of wheeled armoured vehicles.

To accommodate the heavier turret, the Rooikat chassis has been strengthened and lengthened. This chassis is now also being offered for a number of other applications, especially as a platform for a variety of weapon systems.

The hull and turret of the ZA-35 are of all-welded steel construction that provides protection against penetration from 23 mm armour-piercing (AP) rounds over its frontal 60° arc with protection against 7.62 mm AP penetration at a range of 50 m over the remainder of the vehicle. As with all South African armoured vehicles, the ZA-35 has a high degree of protection against mines and can still operate with one wheel blown off each side.

The driver of the ZA-35 is seated at the front, two-man turret in the centre and the powerpack at the rear.

The integrated turret weighs about 11 tons and is totally autonomous with its own diesel power supply unit, it can also be installed on a variety of other chassis, tracked and wheeled.

The commander is seated on the right and the gunner on the left and they share a one-piece hatch cover that opens to the rear with seven periscopes giving observation to the front and sides of the vehicle.

Mounted to the front of the commander, in the roof, is the commander's primary stabilised sight that has been developed by Kentron and designated the AA-CS-300D.

This has continuous 360° traverse and elevation limits from -15 to 75° and two electrically selected magnifications, ×3 and ×10.

The sight, which has a number of other applications, has four modes of operation, independent (commander carrying out surveillance independent of turret movement), dependent (sight line slaved to that of the main weapon or gunner's sight), designate (gunner's sight slaved to that of the commander) and firing (main weapons slaved to that of the commander so enabling him to fire).

The sight also has electrically selectable neutral density filters, a laser protection filter with key fire control data, for example range and mode being displayed in the sight.



ZA-35 twin 35 mm SPAAG in travelling configuration



ZA-35 twin 35 mm SPAAG in operating configuration with radar erected





ZA-35 twin 35 mm SPAAG with front and rear radars erected (Ian Kemp)

Mounted on the forward part of the turret is the Kentron two-axis stabilised electro-optical tracker which provides a video image as well as laser rangefinding for manual and automatic target tracking under day and night conditions.

The electro-optical tracker has three modes of operation. Independent, in which the operator has manual surveillance independent of the base movement, dependent in which the sight line is slaved to that of an external designating source and autotrack in which the sight line is locked onto the target by means of an autotracker.

Sensor choices are TV camera with zoom or fixed optics, low light level TV with fixed optics, thermal imager with switchable fields-of-view, laser rangefinder and missile goniometers or the customer's own sensors. The prototype system has TV cameras with both commander and driver being provided with a TV screen.

The electro-optical tracker is of modular design so that it has other applications and can be upgraded when new technology becomes available. For example, it can be fitted with second level stabilisation for those applications where an even higher degree of stabilisation is required.

The all-electric turret traverse and weapon elevation system has been designed by ESD and is a fully integrated system consisting of independent elevation and traverse systems driven by commands from the fire control system via gun drive controllers and motor drive units. Turret traverse is a full 360° (90° in two seconds) with weapon elevation from -8 to +81°, manual controls are provided for emergency use. The commander and gunner both have dual control handles.

Main armament comprises two M-35 35 mm cannon which are on a common mount and are external of the turret to that of the German Gepard SPAAG with the empty cartridge cases and links being ejected outside the turret.

The gunner can select 1-, 2- or 3-second bursts and a total of 460 rounds of ready use ammunition are carried (230 rounds per gun) which is sufficient for 19 2-second bursts with muzzle velocity being 1175 m/s. It takes eight minutes to reload each magazine and when travelling the cannon can be held in locks. Maximum target engagement is normally around 3500 to 4000 m.

Mounted on the turret rear is the ESD 110 search radar which operates in the L-band and has a multi-track capability. The new radar has two operating positions, when not required the radar is retracted down into the horizontal position at the rear. The maximum height is used when the system is stationary with the medium position used when the vehicle is moving.

This radar has a range of 12 km for aircraft and 6 km against hovering helicopters in a high clutter environment with maximum altitude being 4000 m. The radar has the ability to distinguish between fixed-wing aircraft and helicopters with information being displayed on a plasma display unit which can be seen by both crew members.

The radar provides the crew with an audible warning of hostile aircraft and has ECCM features. The ESD 110 radar can also provide target information to other air defence assets which do not have a radar system, for example manportable SAM systems.

The computerised fire control system includes a digital computer with meteorological/ballistic compensation and memory tracking. In a normal engagement, the target is acquired by the commander and then hands over to the gunner who then tracks the target and opens fire.

The commander's roof-mounted sight has a maximum range of up to 10 km while the electro-optical tracker has a maximum range of up to 8 km, with target identification being up to 75 per cent of these ranges.

System reaction time is quoted as 10 seconds from target detection to target engagement. Extensive communications equipment is fitted and the system can be integrated with other air defence assets and a north reference navigation system is fitted.

Standard equipment includes built-in test equipment (BITE), exhaust



ZA-35 twin 35 mm SPAAG with radar erected and electro-optical module traversed to rear (Ian Kemp)

smoke generator, collective over-pressure biological/chemical system with filters and a ventilation/air-conditioning system which gives a constant 25° internal temperature. A diesel powered auxiliary power unit is fitted as standard and this provides power for such functions as the air-conditioning unit when the main engine is not running. Options for the ZA-35 include an IFF system and a tracking radar.

The first prototype of the ZA-35 is now undergoing trials and if the SADF does move ahead with the programme it is envisaged that two pre-production systems will be built.

A typical air defence troop would consist of three ZA-35 SPAAGs (with troop leader in one) and one ZA-HVM on a similar 8 x 8 chassis (with troop sergeant) with three troops making up a battery with an ESD 1000 radar being deployed at battery level.

The ZA-HVMs would provide top cover for the SPAAGs and commence attrition of the targets before they came into the effective range of the twin 35 mm cannon.

#### SPECIFICATIONS

CREW	3
CONFIGURATION	8 x 8
COMBAT WEIGHT	32 000 kg
LENGTH OVERALL	7.2 m
WIDTH OVERALL	2.9 m
HEIGHT	
radar down	3.1 m
radar up	4.7 m (intermediate); 6 m (maximum)
GROUND CLEARANCE	0.4 m
MAX ROAD SPEED	120 km
ACCELERATION (0 to 30 km/h)	9 s
ROAD RANGE	700 km
GRADIENT	60%
SIDE SLOPE	30%
VERTICAL OBSTACLE	1 m
TRENCH	
crawl speed	2 m
60 km/h	1 m
ENGINE	V-10 water-cooled diesel developing 563 hp
TRANSMISSION	automatic, 6 forward and 1 reverse gears
STEERING	power assisted
TURNING RADIUS	11.25 m
SUSPENSION	internally driven trailing arms, coil springs and shock absorbers
TYRES	14.00 x 20, radial run flat
BRAKES	dual circuit drum on all wheels, retarder on transmission, exhaust brake, crawl brake, parking brake
ELECTRICAL SYSTEM	24 V

**Status:** Prototype. Not yet in production or service.

**Manufacturer:** See text. Enquiries to ARMSCOR, Private Bag X337, Pretoria 0001, South Africa.  
 Telephone: (012) 428 1911  
 Telex: 320217  
 Fax: (012) 428 5635

## South African Crotale Surface-to-Air Missile Upgrade

### Development/Description

The Thomson-CSF Crotale SAM system was originally developed to meet the requirements of the South African Defence Force (SADF) who also funded most of the original development work in France.

Production systems, called the Cactus, were delivered to South Africa between 1971 and 1973 and these remain in service today. Although primarily used for airfield defence, they have also been used to protect the army in the forward area as they have no missiles capable of carrying out this role.

While Kentron can overhaul the Cactus system no new missiles could be supplied and in any case the South African Air Force wanted more capable missiles for the 1990s.

Prime contractor for the Cactus upgrade, which includes repacking into containers, is Synertech. The SA-HVM is being developed by Kentron, while the new computer is being developed by AMS.

The new high velocity missile is called the SA-HVM and has been designed to counter high speed aircraft attacking at altitudes from 100 to 20 000 ft with weapon release ranges from 2000 to 12 000 m. In addition to countering aircraft it can also engage air-to-surface and ship-to-ship missiles according to Kentron.

For compatibility with the existing Cactus fire unit, the SAHV utilises command to line-of-sight guidance although a TV or IR tracker could be added to the launcher to increase operational flexibility. Only minor modifications are required to the Cactus to launch the new missile, mainly changes to the computer software.

The missile has four fixed-wings about two thirds of the way down its cylindrical body with missile control by means of a digital autopilot and electromechanical servo controlling four tail fins. To combat manoeuvring targets, the missile is capable of lateral accelerations of up to 40 g.

The SAHV-3 missile has a high energy smokeless motor which gives the missile a maximum speed of Mach 3.5 and enables it to reach 8 km and 10 seconds or 12 km in 17.5 seconds, in the latter case the missile is still travelling at Mach 1.5.

The missile will be able to engage aircraft before they launch their stand-off weapons, for example engage a target travelling at a speed of Mach 0.95 at 20 000 ft 8 km from the launcher.

The configurable fragmentation warhead weighs 22 kg and has an active electromagnetic fuze to give a 95 per cent hit probability at 10 m from the aircraft target. The fuze can be optimised for engaging aircraft or missile targets.

The SAHV-3 is transported and launched from a sealed container with built-in test functioning for maintenance free operation. There are no launch shoes on the missile which uses lightweight plastic sabot to support it in the launched container.

Using the basic SAHV-3 missile airframe, Kentron state that a complete family of missiles could be developed:

- (1) IR (from Darter air-to-air) or active radar fire and forget
- (2) IR or active radar and lock on after launch
- (3) Medium range SAM with ramjet propulsion
- (4) Vertical launch missile with add-on thrust control unit.

The IR fire and forget missile would be slightly longer and weighs 130 kg and has a nose-mounted two-colour flare resistant auto-scan seeker with a 100° cone and a re-acquisition capability.

The radar homing version would also be slightly longer and heavier and have a nose-mounted fully coherent pulse Doppler seeker with fast acquisition scan and a 90° cone and a home-on-jam mode.

The vertical launch version would clearly have naval applications and would be able to engage anti-ship missiles.

Flight tests of the SAHV-3 commenced in 1991 and according to Kentron, advanced development of the missile will take 18 months to complete with system qualification a further 12 months.

### SAHV-3 MISSILE SPECIFICATIONS

DIAMETER	0.18 m
LENGTH	3.08 m
WING SPAN	0.4 m
WEIGHT	
launch	120 kg
in launch/transport container	159 kg
WARHEAD WEIGHT	22 kg
MANOEUVRABILITY	40 g
MAXIMUM VELOCITY	Mach 3.5
TIME	
to 8 km	10 s
to 6 km	4 s
to 4 km	2 s

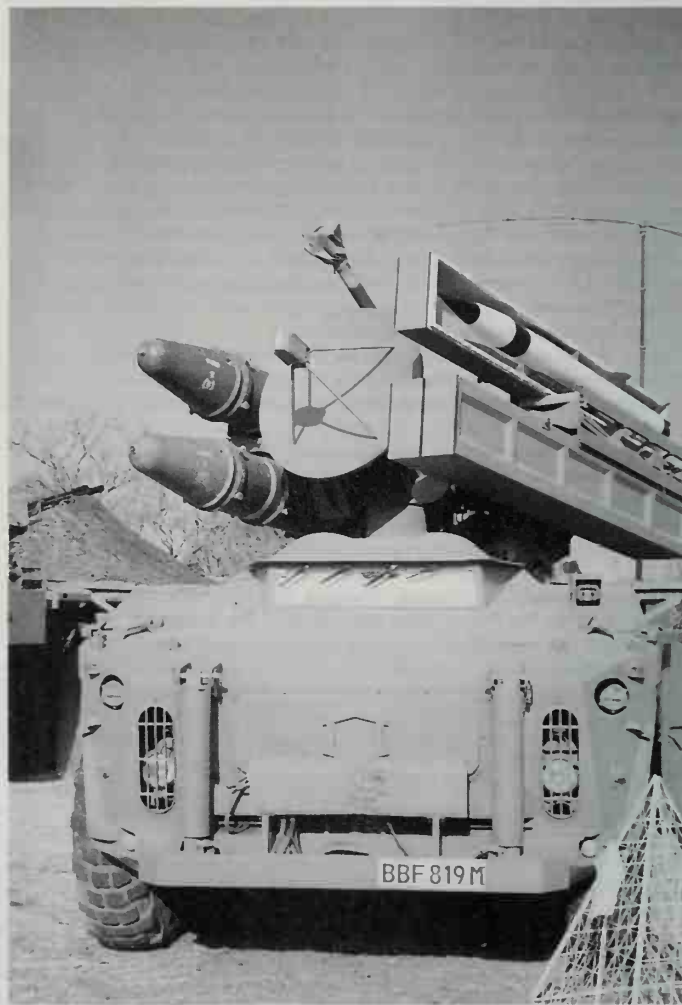
**Status:** Development.

**Manufacturer:** Synertech. Enquiries to ARMSCOR, Private Bag X337, Pretoria 0001, South Africa.

Telephone: (012) 428 1911

Telex: 320217

Fax: (012) 428 5635



SAAF Crotale with two of the new SAHV-3 missiles on one side and two Crotale missiles on the other (Ian Kemp)



Close up of the SAHV-3 missile on a Crotale (Ian Kemp)



## ZA-HVM Self-propelled Surface-to-Air Missile System

### Development/Description

To work with the ZA-35 twin 35 mm SPAAG system, the South African Defence Force formed a requirement for a surface-to-air missile system mounted on a similar chassis and therefore similar cross-country mobility.

This was required to be capable of engaging aircraft flying at a maximum altitude of 20 000 ft and out to a range of 10 km. It was also required to defeat aircraft carrying out toss bomb attacks with a preference for command to line-of-sight (CLOS) control rather than fire and forget.

The ZA-HVM is essentially the ZA-35 with the guns replaced by the same SAHV-3 missiles used in the Crotale upgrade programme being funded by the SAAF. Two missiles would be in the ready to launch position either side of the turret.



ZA-HVM missile system on ZA-35 (8 x 8) chassis

It would have the same surveillance and electro-optical systems as the ZA-35 but could also have a tracking radar to engage beyond the range of the optical tracker.

**Status:** Development. Not yet in production or service.

**Manufacturer:** Kentron. Enquiries to ARMSCOR, Private Bag X337, Pretoria 0001, South Africa.

Telephone: (012) 428 1911

Telex: 320217

Fax: (012) 428 5635



SAHV-3 SAM being launched during initial trials

## NETHERLANDS

### Flycatcher Radar

#### Description

Flycatcher is a self-contained, all-weather search and tracking radar fire control system for low level air defence. The system, which has three independent weapon channels, is designed for one-man operation. Flycatcher, combined with high performance, medium calibre guns, surface-to-air missiles or a combination of both is a highly effective system for sustained operations and all possible means of attack. It can be used in conjunction with any remotely controlled gun or surface-to-air missile system currently available.

The systems I-band MTI search radar, with an effective range of 20 km, is used to detect air targets varying from high speed aircraft to slow-moving or hovering helicopters, drones and even terrain-following missiles. All tracked targets are automatically interrogated and identified by the integrated IFF system.

The high radar resolution enables the system to discriminate between aircraft flying in close formation, while moving target indication clutter suppression circuits eliminate unwanted echoes from trees, buildings, and so on from the PPI display. The tracking beam is wider than the search beam, in order to ensure a quick target take-over within one elevation scan. This I-band beamwidth is compensated for by using an integrated K-band pencil beam for highly accurate, image-free target tracking by the same tracking antenna.

**Status:** Deliveries of the basic Flycatcher to the Royal Netherlands Air Force for defence of air bases and missile batteries began in 1978. Since then several improvements have been implemented. The system has also been delivered to Thailand and several other countries. India has ordered the Flycatcher system for its air defence regiments. After initial production in the Netherlands the equipments are now being manufactured under licence by Bharat Electronics and the first Bharat systems have been



Flycatcher, all-weather low level air defence radar and fire control system

delivered to the Indian Army. A modern version has been delivered to the Royal Netherlands Army.

**Manufacturer:** Hollandse Signaalapparaten BV, Zuidelijke Havenweg 40, PO Box 42, NL-7550 GD Hengelo, Netherlands.

Telephone: (074) 488111

Telex: 44310 SIGN NL

Fax: (074) 425936

## Skyspy Radar

### Description

Skyspy is a land-based version of the Signaal MW 08 naval radar, which is itself a smaller version of the SMART system. It is a G-band 3D multi-beam radar for fully automatic medium/short-range air surveillance, target acquisition and tracking of up to 50 targets. Skyspy features a wide gapless elevation coverage, combined with more than sufficient range for detecting and reacting to low and high incoming targets.



It has a multiple stripline lightweight transmitter/receiver antenna, digital FFT beam former and Doppler FFT processing which reduces susceptibility to clutter and jamming. Eight striplines form the antenna array, and the received signals are processed by eight receiver channels. These come together in a beam forming network in which eight virtual beams are formed, of which six are used for an elevation coverage of 0 to 70°.

**Status:** Signaal has joined forces with LTV Missiles and Electronics Group of USA to provide the Skyspy radar, under the name Skysentry, as the prime sensor in LTV's proposal for the US Army Forward Area Air Defense System (FAADS) competition. A prototype system is being evaluated in the USA. Signaal has also offered the Skyspy 3D radar for the Dutch Army WGL project. The MW 08 system is already in production for the Portuguese and Greek navies.

**Manufacturer:** Hollandse Signaalapparaten BV Zuidelyke Harenweg 40, PO Box 42, NL-7550 GD Hengelo, Netherlands.

Telephone: (074) 488111

Telex: 44310 SIGN NL

Fax: (074) 425936

*Signaal Skyspy 3D radar system in travelling configuration*





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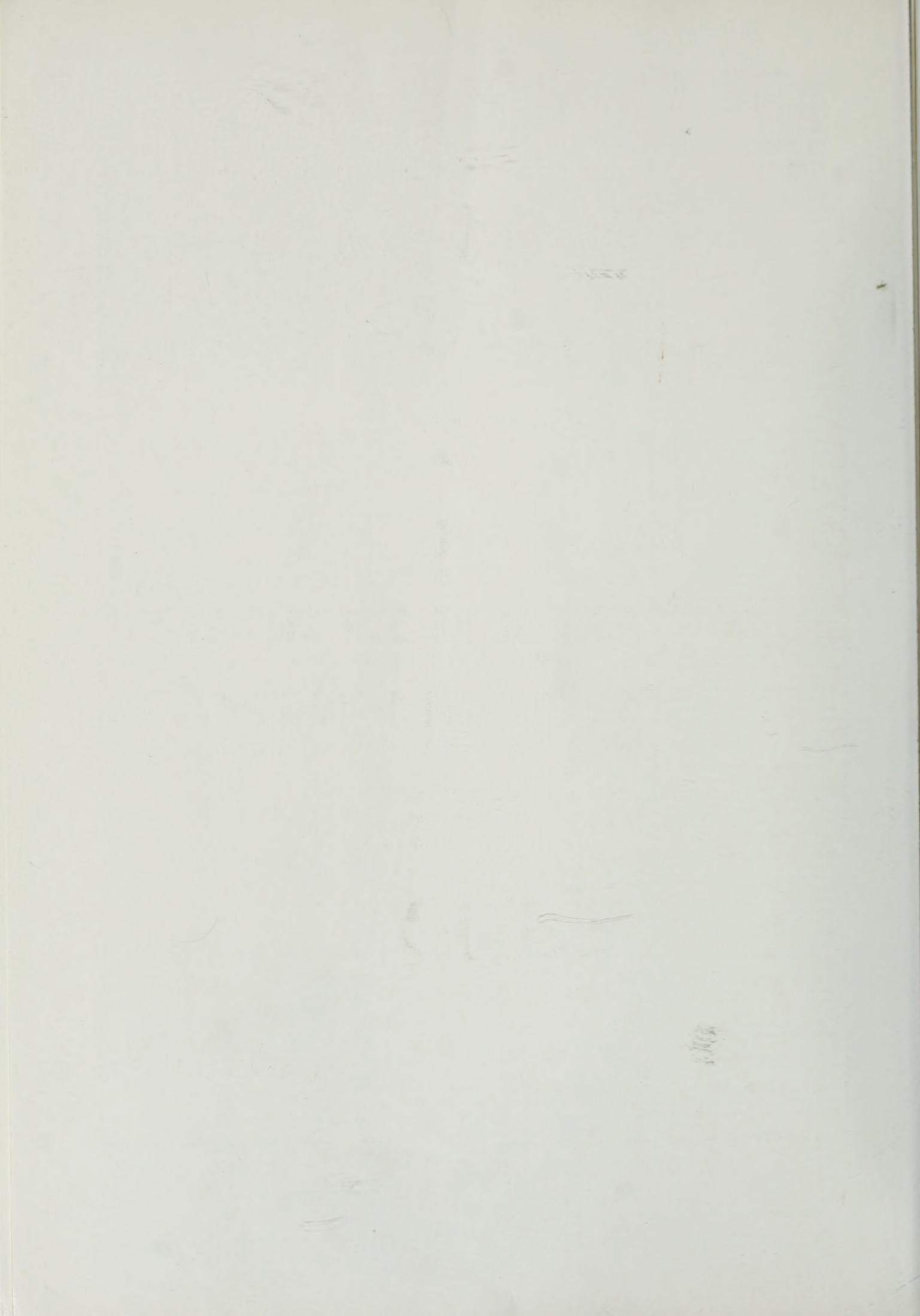
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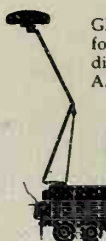
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